I.D. #4640

KEITHLEY

Instruction Manual
Model 169 Digital Multimeter

Contains Operating and Servicing/Calibration Instructions for
Model 169

Keithley Instruments, Inc.
28775 Aurora Road/Cleveland, Ohio 44139/(216) 248-0400

WARRANTY

We warrant each of our products to be free from defects in material and workmanship. Our obligation under this warranty is to repair or replace any instrument or part thereof which, within a year after shipment, proves defective upon examination. We will pay local domestic surface freight costs.

To exercise this warranty, write or call your local Keithley representative, or contact Keithley headquarters in Cleveland, Ohio. You will be given prompt assistance and shipping instructions.

REPAIRS AND CALIBRATION

Keithley Instruments maintains a complete repair and calibration service as well as a standards laboratory in Cleveland, Ohio.

A Keithley service facility at our Munich, Germany office is available for our customers throughout Europe. Service in the United Kingdom can be handled at our office in Reading. Additionally, Keithley representatives in most countries maintain service and calibration facilities.

To insure prompt repair or recalibration service, please contact your local field representative or Keithley headquarters directly before returning the instrument. Estimates for repairs, normal recalibrations and calibrations traceable to the National Bureau of Standards are available upon request.

KEITHLEY

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INSTRUCTION MANUAL

MODEL 169

Digital Multimeter

Contains Operating and Servicing/Calibration Instructions for Model 169

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SECTION 1. GENERAL INFORMATION

1-1. INTRODUCTION.

1-2. The Model 169 is a rugged, low cost, battery-operated digital multimeter that provides full measurement capability for many general purpose applications. It provides accurate readings from 100μV/digit to 1000V on five dc and five ac voltage ranges, 100nA/digit to 2000mA (2 amperes) on five dc and five ac current ranges, and 100mΩ/digit to 20 megohms on six resistance ranges. Ranges and accuracy are listed in the Table of Specifications on page 1-3.

1-3. FEATURES.

1-4. The Model 169 incorporates features that help prevent instrument damage through customer abuse and provide maximum instrument reliability, operator safety and simplicity of operation. Some of these features are:

- A 2000-count (3-1/2 digit) liquid crystal display (LCD) with large 0.6" numerals, function and range annunicators, and a low battery indicator (BAT). Appropriate decimal point and minus sign (-) are also displayed, positive polarity is implied.
- The Model 169 is built rugged. The full bench-size case is molded from impact-resistant and flame-retardant plastic. Effective input protection prevents damage on all functions. Voltage ranges are protected up to 1400V peak, resistance ranges to 300VRMS and current ranges are protected by an externally accessible 2A (250V) fuse.
- Pushbutton switches are color coded to the front panel for quick and easy selection of function and range. The decimal point is automatically positioned by the range pushbutton. Annunciators on the display indicate the selected function and range. Improper range and function combinations are indicated by contradicting function and/or range annunciators appearing at the same time.

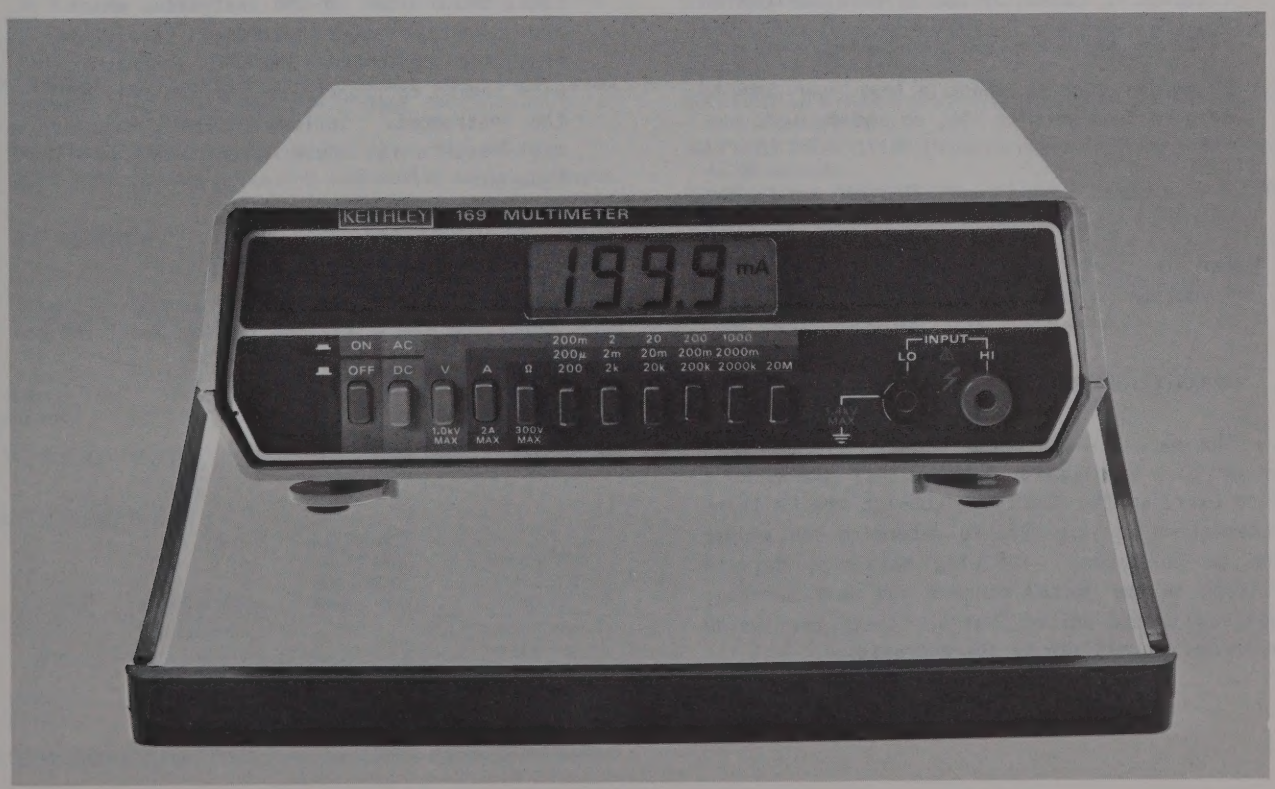


FIGURE 1-1. Model 169.

- The latest LSI technology and stable precision components have been used in the Model 169 to provide long term accuracy and minimize maintenance. Only one calibration adjustment is required, once a year. If alkaline batteries are used, battery life can be the same as the calibration cycle. Barring destructive misuse, an MTBF of up to 20,000 hours can be expected.

- Automatic zeroing, automatic polarity and only two input terminals simplify operation by eliminating potentiometer zeroing and lead changing.

- Optional accessories can be ordered to extend the measurement capability of your Model 169. Some of these are:

  High Voltage Probe allows your DMM to measure from 1000V to 40kV dc.

  High Frequency (RF) Probe allows your DMM to measure from 0.25V to 30V rms ac over a frequency range of 100kHz to 100MHz.

  Clamp-On AC Current Probe allows your DMM to measure from zero to 200A rms ac.

  50-Ampere Current Shunt allows your DMM to measure from zero to 50A, ac and dc.

NOTE

Refer to Section 4 for more detailed information on accessories.

1-5. WARRANTY INFORMATION.

1-6. The warranty is given on the inside front cover of this Instruction Manual. If there is a need to exercise the warranty, contact the Keithley Representative in your area to determine the proper action to be taken. Keithley maintains service facilities in the United Kingdom and West Germany, as well as in the United States. Check the inside front cover of this manual for addresses.

1-7. CHANGE NOTICES.

1-8. Improvements or changes to the instrument which occur after printing of the Instruction Manual will be explained on a Change Notice sheet attached to the inside back cover.

1-9. SAFETY SYMBOLS.

1-10. Safety symbols used in this manual are as follows:

IMPORTANT

The ⚠ symbol can be found in various places in this manual. Carefully read the associated CAUTION statements with regard to proper use and handling of the instrument. Damage to the instrument may occur if these precautions are ignored.

This ↯ symbol can be found in various places in this manual. This symbol indicates those areas on the instrument which are potential shock hazards. Carefully read the associated WARNING statements with regard to proper use and handling of the instrument. Serious personal injury may result if these precautions are ignored.

1-11. SPECIFICATIONS.

1-12. Detailed specifications for the Model 169 are given in Table 1-1.

TABLE 1-1.

Specifications Model 169

DC VOLTAGE

RANGE	RESOLUTION	ACCURACY (1 YEAR) 18°—28°C
200mV	100μV	
2 V	1mV	
20 V	10mV	±(0.25% of reading + 1 digit)
200 V	100mV	
1000 V	1 V	

MAXIMUM ALLOWABLE INPUT: 1000VDC, 1400V peak AC.
INPUT RESISTANCE: 10MΩ.
NORMAL MODE REJECTION RATIO: Greater than 50dB at 50Hz, 60Hz.
COMMON MODE REJECTION RATIO: Greater than 100dB at DC, 50Hz and 60Hz (1kΩ unbalance, 500V).

AC VOLTAGE

RANGE	RESOLUTION	ACCURACY (1 YEAR) 18°—28°C 45Hz—1kHz	1kHz—5kHz
200mV	100μV		
2 V	1mV		
20 V	10mV	±(0.75% rdg + 5d)	±(5% rdg + 7d)
200 V	100mV		
1000 V	1 V		

MAXIMUM ALLOWABLE INPUT: 1000V rms, 1400V peak, 10^6V•Hz, continuous except 200mV range: 350V continuous, 15 sec. maximum above 350V.
INPUT IMPEDANCE: 10MΩ shunted by less than 100pF.
RESPONSE: Average responding, calibrated in rms of a sinewave.

DC CURRENT

RANGE	RESOLUTION	ACCURACY (1 YEAR) 18°—28°C	MAXIMUM VOLTAGE BURDEN
200μA	100nA		0.25V
2mA	1μA		0.25V
20mA	10μA	±(0.75% rdg + 1d)	0.25V
200mA	100μA		0.3 V
2000mA	1mA		0.7 V

OVERLOAD PROTECTION: 2A fuse (250V), externally accessible.

AC CURRENT

RANGE	RESOLUTION	ACCURACY (1 YEAR) 18°—28°C (45Hz—1kHz)	MAXIMUM VOLTAGE BURDEN
200μA	100nA		0.25V rms
2mA	1μA		0.25V rms
20mA	10μA	±(1.5% rdg + 5d)	0.25V rms
200mA	100μA		0.3 V rms
2000mA	1mA		0.7 V rms

OVERLOAD PROTECTION: 2A fuse (250V), externally accessible.

RESISTANCE

RANGE	RESOLUTION	ACCURACY (1 YEAR) 18°—28°C	FULL SCALE VOLTAGE
200 Ω	100mΩ	±(0.3% rdg + 3d)	< 0.5V
2k Ω	1 Ω	±(0.2% rdg + 1d)	< 0.5V
20k Ω	10 Ω	±(0.2% rdg + 1d)	> 0.7V
200k Ω	100 Ω	±(0.2% rdg + 1d)	> 0.7V
2000k Ω	1k Ω	±(0.2% rdg + 1d)	> 0.7V
20MΩ	10k Ω	±(2.0% rdg + 1d)	> 0.7V

MAXIMUM OPEN CIRCUIT VOLTAGE: 1.5V except 200Ω range: 3.5V.
MAXIMUM ALLOWABLE INPUT: 300V DC or rms.

GENERAL

DISPLAY: 3½-digit LCD, 0.6" numeral height, with polarity, range and function indicators.
OVERRANGE INDICATION: 3 least significant digits blanked.
MAXIMUM COMMON MODE VOLTAGE: 1400V peak.
OPERATING ENVIRONMENT: 0° to 50°C; less than 80% RH up to 35°C, less than 70% RH from 35° to 50°C.
STORAGE ENVIRONMENT: −35° to 60°C.
TEMPERATURE COEFFICIENT (0°—18°C and 28°—50°C): Less than 0.1 × applicable accuracy specification, per °C.
POWER: Six 1.5V "C" cells.
BATTERY LIFE: 1000 hours typical with carbon zinc cells; 2000 hours with alkaline cells.
BATTERY INDICATOR: Display indicates "BAT" when less than 5% of life remains.
DIMENSIONS, WEIGHT: 85mm high × 235mm wide × 275mm deep (3½" × 9¼" × 10¾"). Net weight 1.4kg (3 lbs.).
ACCESSORIES AVAILABLE:

- 1691 General Purpose Test Lead Set
- 1699 Spare Parts Kit to Maintain 10 169's for 1 Year
- 1600 High Voltage Probe
- 1651 50-Ampere Shunt
- 1681 Clip-On Test Lead Set
- 1682 RF Probe
- 1683 Universal Test Lead Kit
- 1684 Hard Shell Carrying Case
- 1685 Clamp-On Current Probe

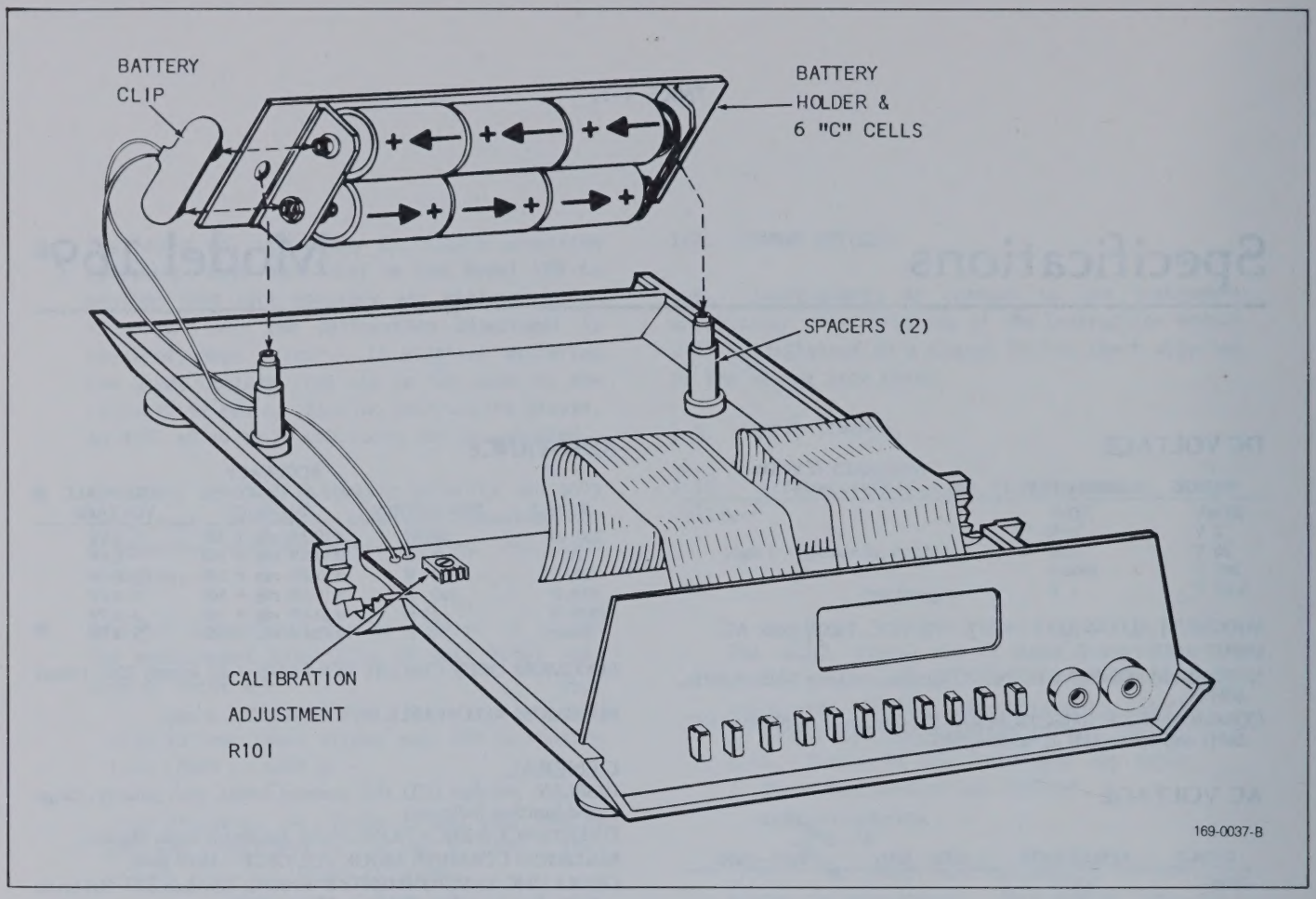


FIGURE 2-1. Installation of Batteries.

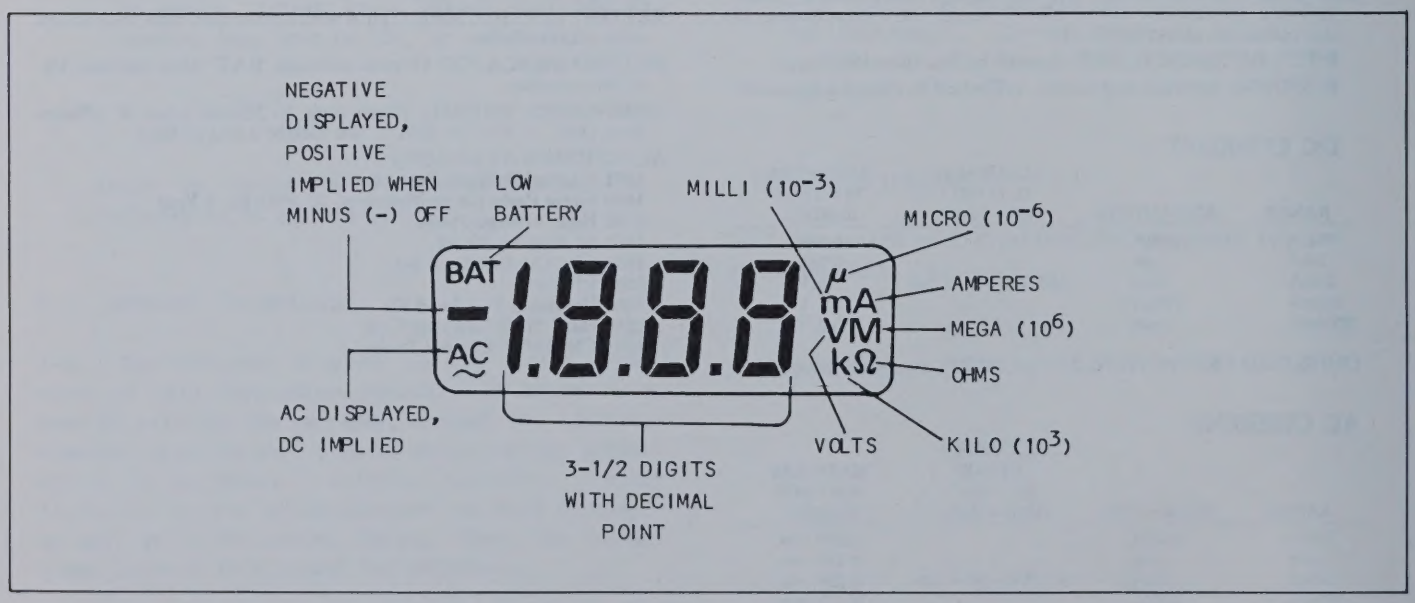


FIGURE 2-2. Model 169 Front Panel Display.

SECTION 2. OPERATION

2-1. INTRODUCTION.

2-2. This section provides information needed for incoming inspection, preparation for use and operation of the Model 169 and its accessories.

2-3. UNPACKING AND INSPECTION.

2-4. The Model 169 was carefully inspected, both mechanically and electrically before shipment. Upon receiving the Model 169, unpack all items from the shipping container and check for any obvious damage which may have occured during transit. Report any damages to the shipping agent. Retain and use the original packaging materials if reshipment is required. The following items are shipped with all Model 169 orders:

a. Model 169 DMM

b. Six carbon zinc "C" cells (may be shipped installed in the DMM in some units).

c. A copy of this Manual.

d. Separate optional accessories, as ordered.

2-5. PREPARATION FOR USE.

2-6. Installation of Batteries, if required.

WARNING

To prevent a shock hazard, all test leads should be removed from the INPUT terminals before removing the instrument top cover.

a. Turn the DMM bottom side-up and loosen the four screws in the bottom cover until the threads are not engaged. NOTE: The screws are not retained and they will fall out when the instrument is returned to its normal position.

b. Hold the top and bottom cover together to prevent their separation and turn the DMM cover to normal position. Lift off the top cover.

NOTE

Carbon-zinc batteries are supplied. These batteries will operate your DMM for approximately 1000 hours. If it is desired to change batteries only once a year when calibration is required, alkaline cells may be substituted. These cells will provide approximately 2000 hours of operation. In either case, the low battery indicator will automatically come on with approximately 5% of battery life remaining (20 hours for carbon-zinc and 40 hours for alkaline cells).

c. Install the batteries in the holder as shown in Figure 2-1.

d. Press the battery clip onto the terminals of the battery holder; then position battery holder on the two spacers as illustrated.

e. Reinstall the top cover.

f. After the batteries are installed, you should become familiar with the Model 169 by reading the section titled Controls, Indicators and Connectors (Paragraph 2-7); then perform the Initial Functional Check (Paragraph 2-16).

2-7. CONTROLS, INDICATORS AND CONNECTORS.

2-8. Display.

2-9. The operating status of the Model 169 is continuously provided by the 3-1/2 digit (2000 count) liquid crystal display located on the front panel. In addition to the digitized input signal, with appropriate decimal point and polarity, the display provides indications of the selected function and range, battery condition and overrange. All indicators on the display are shown in Figure 2-2 and described as follows.

a. Numerals. Large 0.6" numerals display up to a maximum of 1999 counts. Leading zero is only suppressed for most significant (1/2) digit.

b. Decimal Point. The decimal point is indicated in three positions and implied when behind the least significant digit. The decimal point is properly positioned when a range pushbutton is pressed.

c. Overrange. A "1" followed by three blanked digits is displayed as an overrange indication for all ranges and functions, except the 1000 volt ranges which read beyond their maximum allowable input voltages. The minus sign and a decimal point may also be displayed, if appropriate.

d. Polarity. For dc measurements the minus sign (-) is displayed, positive is implied. The minus sign may flash on any function at zero since it is not suppressed. It is also normal for it to flash in ohms while the instrument is recovering from overrange.

e. Low Battery Indication. BAT is displayed when approximately 5% of battery life remains. This indicates that the batteries should be replaced, however the Model 169 will continue to operate properly for 40 hours if alkaline cells are installed, or 20 hours if carbon-zinc cells are installed.

f. Function and Range Annunciators. These indicators provide a continuous display of the selected function and range, and allow direct reading of the display. For example: a displayed half-scale ac current on the highest current range would read AC 1000mA.

NOTE

Extended exposure of the liquid crystal display to direct sunlight, or high temperature and high humidity conditions can cause the display to temporarily blacken. Also, the display may become sluggish if exposed to extremely cold temperatures. Even though recovery occurs at normal operating temperatures, these conditions should be avoided for maximum display life.

2-10. Front Panel Switches.

2-11. Control of the Model 169 is provided by eleven pushbutton switches which are color coordinated to the front panel. These switches are shown in Figure 2-3 and described as follows.

a. ON/OFF Pushbutton. Push on - push off switch that, when in, applies power to the DMM.

b. Function Pushbuttons. The four function pushbuttons provide selection of the five functions of the Model 169. AC/DC is a push on - push off switch that selects whether the function is ac or dc, in for ac or out for dc. When ac is selected, the AC annunciator is on. When the annunciator is off, dc is implied. The AC/DC pushbutton is not effective when ohms (Ω) is selected. The V, A and Ω pushbuttons are push-on switches that select volts, amperes and ohms, respectively. Pressing one of these pushbuttons all the way in selects the new function, turns on the proper annunciator and cancels the previously selected function. Note that it is possible, by forcing, to push two pushbuttons in at the same time. This will be evidenced by conflicting range/function annunciators appearing, and the unwanted function can be canceled by pressing the desired function pushbutton again.

c. Range Pushbuttons. The six range pushbuttons are push-on switches which select the new range and cancel the previous one. The decimal point is positioned and the appropriate annunciator is turned on when the range is selected. The 20M pushbutton is only used for ohms function. If it is inadvertently selected with volts or current, contradicting annunciators will appear.

2-12. Input Connections.

2-13. Two banana jacks provide the input connections to the Model 169. The HI (red) jack is the high impedance input and is normally connected to the point in the test circuit most removed from signal or earth ground. The LO (black) jack is the common or low input.

TABLE 2-1
Initial Function Check

STEP	SELECTION FUNCTION	SELECTION RANGE	DMM INPUT	DISPLAY READING	REMARKS
1			Open	000	Power on, all other switches out. (-) may flash.
2	ACV	200mV	Shorted	00.0 ACmV	
3	DCV	200mV	Shorted	00.0 mV	
4	A and Ω*	2k	Open	.100 mAkΩ	Display reads 2mA current shunt on 2kΩ range. Checks current fuse.
5	A and Ω*	200Ω and 2mA	Open	1.00.0 μAΩ	Display reads 2mA current shunt on 200Ω range. (approx. 100Ω)
6	A and Ω*	200Ω and 20mA	Open	1.0.0 μAΩ	Display reads 20mA current shunt on 200Ω range. (10Ω)
7	Ω	20M	Shorted	0.00 MΩ	
8	Ω	2000k	Shorted	000 kΩ	
9	Ω	2000k	Open	1 kΩ	Overrange indication, leading 1 with all other digits blanked.

*Press both pushbuttons simultaneously.

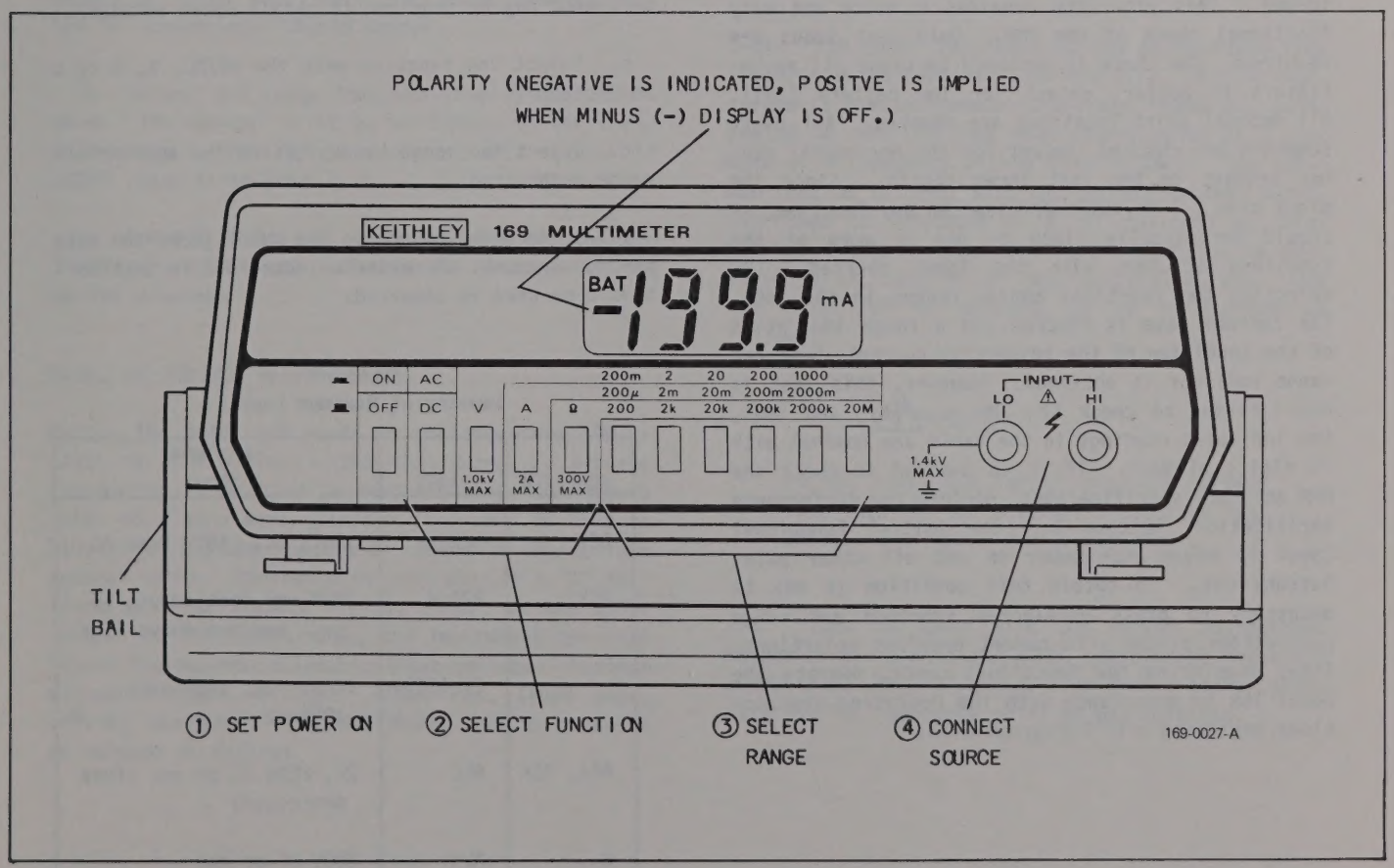


FIGURE 2-3. Operating Controls.

WARNING

To avoid electrical shock and/or instrument damage, do not connect the LO input to any source of more than 1400 volts (peak) above earth ground.

2-14. Tilt Bail/Handle.

2-15. The 16 position tilt bail/handle allows you to position the instrument for the best viewing angle of the display.

2-16. INITIAL FUNCTIONAL CHECK.

2-17. Now that the batteries are installed and you have become familiar with your DMM, the initial checkout procedure given in Table 2-1 should be performed. This procedure provides a quick and easy functional check of the DMM. Only test leads are required. The check is designed to cause all annunciators to appear, except for low battery (BAT). All decimal point locations are checked. All digit segments are checked, except for the horizontal center segment on the last three digits. Since the minus sign (-) is not suppressed on any function, it should periodically flash on one or more of the functions at zero with the input shorted. By selecting two functions and/or ranges in the test, the current fuse is checked and a rough indication of the condition of the respective current shunt and range resistor is obtained. However, this test is not intended to check the DMM accuracy, and thus, the indicated readings in the table are nominal with ±5 digits allowed. If it is desired to check the DMM accuracy specifications, perform the Performance Verification, Section 3. The Initial Functional Check is begun with power on and all other pushbuttons out. To obtain this condition it may be necessary to press unselected function and range pushbuttons slightly to cancel previous selections. After completing the functional check, operate the Model 169 in accordance with the Operating Instructions beginning with Paragraph 2-18.

2-18. OPERATING INSTRUCTIONS.

2-19. The basic operating instructions for the Model 169 DMM are outlined below. In addition, there are individual instructions provided in this section which describe how to make specific function measurements. Refer to Figure 2-3 and operate the DMM as follows.

CAUTION

Do not exceed the maximum input limits given in Table 2-2.

a. Turn on power by depressing the ON/OFF pushbutton. If the instrument is within 18-28°C, it is useable immediately to rated accuracy. If the ambient temperature is within 18-28°C range, but the DMM has been subjected to temperature extremes, up to 1 hour may be required to obtain rated accuracy.

b. Select the function with the AC/DC, V, A or Ω pushbuttons.

c. Select the range by depressing the appropriate range pushbutton.

d. Connect the source to the INPUT jacks and make the measurement. Accessories described in Section 4 should be used as required.

TABLE 2-2
Summary of Maximum Inputs

FUNCTION	RANGE	MAXIMUM INPUT
DCV	ALL	1000V DC, 1400V Peak AC
ACV	200mV	350V rms continuous, 15 sec. maximum above 350V
	2V-1000V	1000V rms, 1400 peak, 10^6V·Hz
ACA, DCA	ALL	2A, 250V DC or rms (fuse protected)
Ω	ALL	300V DC or rms

2-20. DC VOLTAGE MEASUREMENT.

2-21. The Model 169 reads dc voltage from 100µV/digit to 1000 volts. The maximum displayed reading is 1999 with appropriate decimal point. Polarity is automatically sensed and the minus sign (-) will be displayed, if applicable. Overrange is indicated by a "1" and three blanked digits, except on the 1000V range. On the 1000V range, the display can read beyond the maximum allowable input voltage. Maximum allowable input: 1000V dc, 1400 peak ac. Use the Model 169 to measure dc voltage as follows:

⚠ CAUTION

Do not exceed the maximum allowable input voltage. Instrument damage may occur.

a. Turn on power with the ON/OFF pushbutton; select dc volts with the V and AC/DC pushbuttons. The "V" annunciator should appear.

b. Select the range from the five ranges available. The decimal point is positioned by the range pushbutton. The "m" annunciator will appear if 200mV range is selected.

c. Connect the signal to be measured between the INPUT HI and LO jacks; observe the voltage reading on the display.

2-22. AC VOLTAGE MEASUREMENT.

2-23. The Model 169 reads ac voltages from 100µV/digit to 1000 volts. The instrument is average responding, calibrated to read the root mean square value of a sine wave within a frequency of 45Hz to 5kHz. The maximum reading is 1999 with appropriate decimal point. Overrange is indicated by a "1" followed by three blanked digits, except on the 1000V range. On the 1000V range, the instrument can read beyond the maximum allowable input voltage. Maximum allowable input voltage: 1000V rms, 1400V peak, 10^6V·Hz maximum. Use the Model 169 to measure ac voltage as follows.

⚠ CAUTION

Do not exceed the maximum allowable input voltage. Instrument damage may occur.

a. Turn on power with the ON/OFF pushbutton; select ac volts with the V and AC/DC pushbuttons.

b. Select the range from the five ranges available. The decimal point is positioned by the range pushbuttons. The "m" annunciator will appear if 200mV range selected.

c. Connect the signal to be measured between the INPUT HI and LO jacks; observe the voltage reading on the display.

2-24. AC OR DC CURRENT MEASUREMENT.

2-25. The Model 169 reads ac and dc currents from 100nA/digit to 2000 milliamperes (2A). For ac measurements the instrument is average rsponding, calibrated to read the root mean square value of a sine wave of a frequency within 45Hz to 1kHz. The maximum reading is 1999, with appropriate decimal point. Overrange is indicated by a "1" followed by three blanked digits. Input overload protection is provided by 2A, 250V dc or rms, quick-blow fuse. Use the Model 169 to measure, ac or dc current as follows.

⚠ CAUTION

Do not install a larger capacity current fuse than the one originally supplied (2A, 250V). Instrument damage may occur.

a. Turn on power with the ON/OFF pushbutton. Select ac or dc with the AC/DC pushbutton; depress A pushbutton. The "A" annunciator should appear along with the "AC" annunicator if ac was selected.

b. Select the range from the five ranges available. The decimal point is positioned by the range pushbutton. The "μ" annunciator will appear if 200μA range was selected; otherwise, the "m" annunciator will appear. It should be noted that the voltage drop across the current shunt in the instrument (called voltage burden) can affect the circuit under test if it has a low source voltage. This voltage burden can be reduced by selecting the highest current range that will resolve the desired measurement.

c. Connect the signal to be measured to the INPUT HI and LO jacks; observe the current reading on the display.

2-26. RESISTANCE (Ω) MEASUREMENT.

2-27. The Model 169 reads resistance from 100mΩ/digit to 20 megohms. The maximum reading is 1999 with appropriate decimal point. Overrange is indicated by a "1" followed by three blanked digits. Maximum Allowable Input: 300V dc or rms. Use the Model 169 to measure resistance as follows.

⚠ CAUTION

Turn the test circuit off and discharge all capacitors before attempting in-circuit measurements. A voltage may be present in the circuit if either the minus sign is displayed, along with a steady displayed number other than zero, or the reading changes more than two digits when the leads are reversed.

a. Turn on power and depress the Ω pushbutton. The "Ω" annunciator should appear.

b. Connect the circuit to be measured to INPUT HI and LO and select the desired range from the six ranges available. The decimal point is positioned by the range pushbutton and the applicable range annunciator should appear.

c. Read the resistance on the display. If the 200Ω range is selected, disconnect the test leads at the test circuit, short them together and subtract the reading obtained from the reading obtained above.

NOTE

As previously mentioned for in-circuit measurements, the presence of a voltage will cause a change in the reading when the leads are reversed. The presence of a forward biased semiconductor junction will also cause a significant error, and therefore, it is a good practice to reverse the leads and make comparative measurements of in-circuit resistances. In addition, it should be noted that the bottom two resistance ranges will not turn on most semiconductors, except in an overrange condition.

d. Diode Tests. Any of the top four ohms ranges will turn on semiconductor junctions, with an on-scale reading, but the 20KΩ range is recommended for out-of-circuit tests of semiconductors because its test current is higher. To test a junction, first forward bias it and then reverse bias it while observing the display reading for both conditions. The HI jack is positive. Compare the results as follows:

INDICATION	JUNCTION CONDITION
1. Overrange, both Polarities	OPEN
2. Low reading, both polarities	SHORTED
3. Overrange when reverse biased and an on-range reading when forward biased	PROBABLY GOOD

SECTION 3. PERFORMANCE VERIFICATION

3-1. GENERAL.

3-2. Performance verification may be performed upon receipt of the instrument to ensure that no damage or misadjustment has occured during transit. Verification may also be performed whenever there is question of the instrument's accuracy, and following calibration, if desired.

NOTE

For instruments that are still under warranty (less than 12 months since date of shipment), contact your Keithley representative or the factory immediately if the instrument falls outside of specifications as determined by the Performance Verification Procedure in paragraph 3-7.

3-3. RECOMMENDED TEST EQUIPMENT.

3-4. Recommended test equipment for performance verification (and calibration) is listed in Table 3-1. Alternate test equipment may be used. However, if the accuracy of the alternate test equipment is not at least 10 times better than the instrument specifications, additional allowance must be made in the readings obtained.

3-5. ENVIRONMENTAL CONDITIONS.

3-6. All measurements should be made at an ambient temperature within the range of 18° to 28°C (65° to 82°F), and a relative humidity of less than 80%.

3-7. PERFORMANCE VERIFICATION PROCEDURE.

3-8. Use the following procedures to verify the basic accuracy of the Model 169 for voltage, resistance and current measurements.

TABLE 3-1
Recommended Test Equipment for Performance Verification.

ITEM	DESCRIPTION	SPECIFICATIONS	MFR.	MODEL
A	DC Calibrator	0.1V, 1V, 10V, 100V 1000V, ±0.005%	Fluke	341A
B	AC Calibrator	0.1V, 1V, 10V, 100V ±0.022%	H-P	745A
C	AC Calibrator/Amplifier	1000V ±0.04%	H-P	745A/746A
D	Decade Resistor	1.9kΩ, 19kΩ, 190kΩ, 1.9MΩ, 10MΩ, ±0.02%	ESI	DB62
E	Current Calibrator	100μA, 1mA, 10mA, 100mA, 1A, ±0.03%	Valhalla	2500

NOTE

Performance verification should be performed by qualified personnel using accurate and reliable test equipment.

3-9. Initial Conditions.

3-10. Before beginning the verification procedure the instrument must meet the following conditions:

a. If the instrument has been subjected to extremes of temperature, allow internal temperature to stabilize for one (1) hour minimum at the environmental conditions specified in paragraph 3-5.

b. Turn the instrument on and check for low battery indication. If low battery indicator (BAT) is on, remove and replace the batteries with fresh ones.

WARNING

Some procedures require the use of high voltage. Take care to prevent contact with live circuits which could cause electrical shock resulting in injury or death.

3-11. DC Volts Checkout.

a. Select dc voltage readings with the AC/DC and V pushbuttons.

b. Connect the DC Calibrator (Item A, Table 3-1) to the instrument.

c. Select the 200mV range, and apply positive 100mVdc to the DMM. The reading must be within the limits specified in Table 3-2.

d. Select each remaining range and apply the required voltage as specified in Table 3-2, verify that the reading is within specifications.

e. Repeat all checks with negative voltage.

TABLE 3-2
DC Voltage Performance Check

Range	Applied Voltage	Allowable Reading at 18° to 28°C
200mV	100.00 mV	99.6 to 100.4
2 V	1.0000 V	.996 to 1.004
20 V	10.000 V	9.96 to 10.04
200 V	100.00 V	99.6 to 100.4
1000 V	1000.0 V	996 to 1004

3-12. AC Volts Checkout.

a. Select ac voltage readings with the AC/DC and V pushbuttons.

b. Connect the AC Calibrator (Item B, Table 3-1) to the DMM. Set the calibrator frequency to 1kHz.

c. Set the DMM to the 200 mV range and apply 100 mV ac to the DMM. The reading must be within the limits specified in Table 3-3.

d. Select the 2, 20 and 200 volt ranges and apply the required voltages as specified in Table 3-3. Verify that the readings are within specifications.

e. To check the 1000 volt range, connect the AC Calibrator Amplifier (Item C, Table 3-1) to the output of 1000 volts ac rms and verify that the DMM reading is within the specified limits.

TABLE 3-3
AC Voltage Performance Check

Range	Applied Voltage	Allowable Reading at 18° to 28°C
200mV	100.00 mV	98.7 to 101.3 mV
2 V	1.0000 V	.987 to 1.013 V
20 V	10.000 V	9.87 to 10.13 V
200 V	100.00 V	98.7 to 101.5 V
1000 V	1000.0 V	987 to 1013 V

3-13. Resistance Checkout.

a. Select resistance readings by pressing the Ω pushbutton.

b. Select the 200 Ω range.

c. Connect the decade resistor (Item D, Table 3-1) to the DMM.

d. Set the decade resistor to zero and measure the resistance of the test leads. Subtract this reading from the display in all of the following steps.

e. Set the decade resistance to 190.0. Verify that the reading is within the limits specified in Table 3-4.

f. Continue the resistance check by selecting the next range and measuring the next resistance as specified in Table 3-4. Verify that the reading is within specifications. Test each item in the table.

TABLE 3-4
Resistance Performance Check

Range	Resistance	Allowable Reading at 18° to 28°C
200 Ω	190.0 Ω	189.1 to 190.9 Ω
2 kΩ	1.900kΩ	1.895 to 1.905 KΩ
20 kΩ	19.00kΩ	18.95 to 19.05 KΩ
200 kΩ	190.0kΩ	189.5 to 190.5 KΩ
2000 KΩ	1.900kΩ	1895 to 1905 KΩ
20 MΩ	10.00MΩ	9.79 to 10.21 MΩ

3-14. DC Current Checkout.

a. Select dc current readings with the AC/DC and A pushbuttons.

b. Connect the dc current source (Item E, Table 3-1) to the DMM.

c. Select the 200μA range and apply a current of 100.00μA to the DMM. The reading must be within the limits in Table 3-5.

d. Select each range and apply the required current as specified in Table 3-5. Verify that the reading is within specifications.

3-15. ANALYSIS.

3-16. If the instrument is out of the specified limits given in Tables 3-2 through 3-5, either troubleshooting and repair or calibration, as described in Section 6, may be required. Normally, recalibration will only be the indicated solution when the instrument is out of specification on more than one function (except for the higher ranges of DC volts which are the most critical). If the instrument is still under warranty, refer to the Note in Paragraph 3-2.

TABLE 3-5
DC Current Performance Check

Range	Applied Current	Allowable Reading at 18° to 28°C
200 μA	100.00 μA	99.1 to 100.9 μA
2 mA	1.0000 mA	.991 to 1.009 mA
20 mA	10.000 mA	9.91 to 10.09 mA
200 mA	100.00 mA	99.1 to 100.9 mA
1000 mA	1000.0 mA	991 to 1009 mA

SECTION 4. ACCESSORIES

4-1. GENERAL.

4-2. This section describes the various accessories and options available for use with the Model 169 DMM.

4-3. MODEL 1600 HIGH VOLTAGE PROBE.

4-4. The Model 1600 High Voltage Probe (shown in Figure 4-1) extends the measurable dc voltage range up to 40 kilovolts. It has a 1000:1 division ratio, so that a reading of 1 volt on the DMM corresponds to 1 kilovolt (1000 volts). To use the probe, select DCV and the required range, connect the high voltage probe banana plug to the instrument, connect the alligator clip to source low, and touch the probe tip to source high.

WARNING

Be sure the alligator clip is connected to source low before touching probe tip to source high. A shock hazard or damage to instrument may result.

Specifications

Voltage Range: 0 to 40,000 volts DC.
Input Resistance: 1000 megohms.
Division Ratio: 1000:1.
Ratio Accuracy:
±1.5% at 25kV, decreasing to
±2.0% at 20kV and 30kV,
±3.0% at 10kV and 40kV, and
±4.0% at 1kV.
Ratio Stability: ±0.01% per °C; ±0.1% per year.
Heating Effects: Self-heating due to application of high voltage for period in excess of 1 minute will cause a maximum of 0.2% additional error at 40kV (error is less at lower voltage).

4-5. MODEL 1651 50-AMPERE SHUNT

4-6. The Model 1651 50-Ampere Shunt (shown in Figure 4-2) permits current measurements of up to 50 amperes ac or dc. The shunt has a resistance of 0.001 ohm ±1%, so that a 50-ampere current will correspond to a reading of 50 millivolts (0.0500 volt). Set the DMM to ACV or DCV and select the required range. To use the shunt, connect the leads furnished with the shunt from the shunt screw terminals to the DMM input terminals. Use separate leads (not furnished) to connect the source to the hex head bolts. Be sure to use leads with a capacity of 50 amperes, or as needed.

4-7. MODEL 1681 CLIP-ON TEST LEAD SET

4-8. This set (shown in Figure 4-3) contains two leads with banana plugs at one end and spring-action clip-on probes at the other end. To use, insert the banana plugs into the DMM and attach the probes to the source.

4-9. MODEL 1682 RF PROBE

4-10. The Model 1682 RF Probe (shown in Figure 4-1) permits measurement of ac voltages at frequencies of 20 kilohertz to 100 megahertz. Connect the probe to the input terminals and select DCV and the appropriate range.

Specifications

Voltage Range: 0.25 to 30 volts rms.
Transfer Accuracy: ±0.5dB, 100kHz to 100MHz peak responding calibrated in rms of a sinewave.
Input Impedance: 4 megohm shunted by 3pF.
Maximum Allowable Input: 30V rms AC, 200V DC.
Accessories Supplied: straight-tip, hook tip, ground clip, hi adapter, banana plug adapter.

4-11. MODEL 1683 UNIVERSAL TEST LEAD KIT.

4-12. This kit (shown in Figure 4-3) contains two test leads and 12 screw-in adapter tips. The tips consist of two alligator tips with boots, two banana plugs, two needle tips with chucks, two spade lugs and four heavy duty tip plugs which permit connection of the DMM to virtually any source within its measurement range.

4-13. MODEL 1684 CARRYING CASE.

4-14. The Model 1684 Carrying Case (shown in Figure 4-4) is a hard vinyl case with a fitted foam insert to help protect the Model 169 from damage. There is also room in the case for the Instruction manual and small accessories

4-15. MODEL 1685 CLAMP-ON AC CURRENT PROBE.

4-16. The Model 1685 Clamp-On AC Current Probe (shown in Figure 4-2) permits measurement of ac current by clamping around a single conductor, eliminating the need to interrupt the current path. Plug the ac current probe into the DMM and select ACV and the appropriate range. The DMM will display 0.1 volt rms per ampere.

4-17. MODEL 1691 GENERAL PURPOSE TEST LEAD SET.

4-18. The Model 1691 General Purpose Test Lead Set (shown in Figure 4-3) consists of two .91m (36 inches) test leads with probe tips terminated in banana plugs.

4-19. MODEL 1699 SPARE PARTS KIT.

4-20. The Model 1699 contains a complement of spare parts that will maintain up to 10 Model 169 DMMs for one year. The parts are listed in Table 7-1 of Section 7, Replaceable Parts.

4-21. MODELS 1010 and 1017 RACK MOUNTING KITS.

4-22. The rack mounting kits (shown in Figure 4-4) permit mounting one or two Model 169 DMMs in a 19-inch rack for convenient viewing.

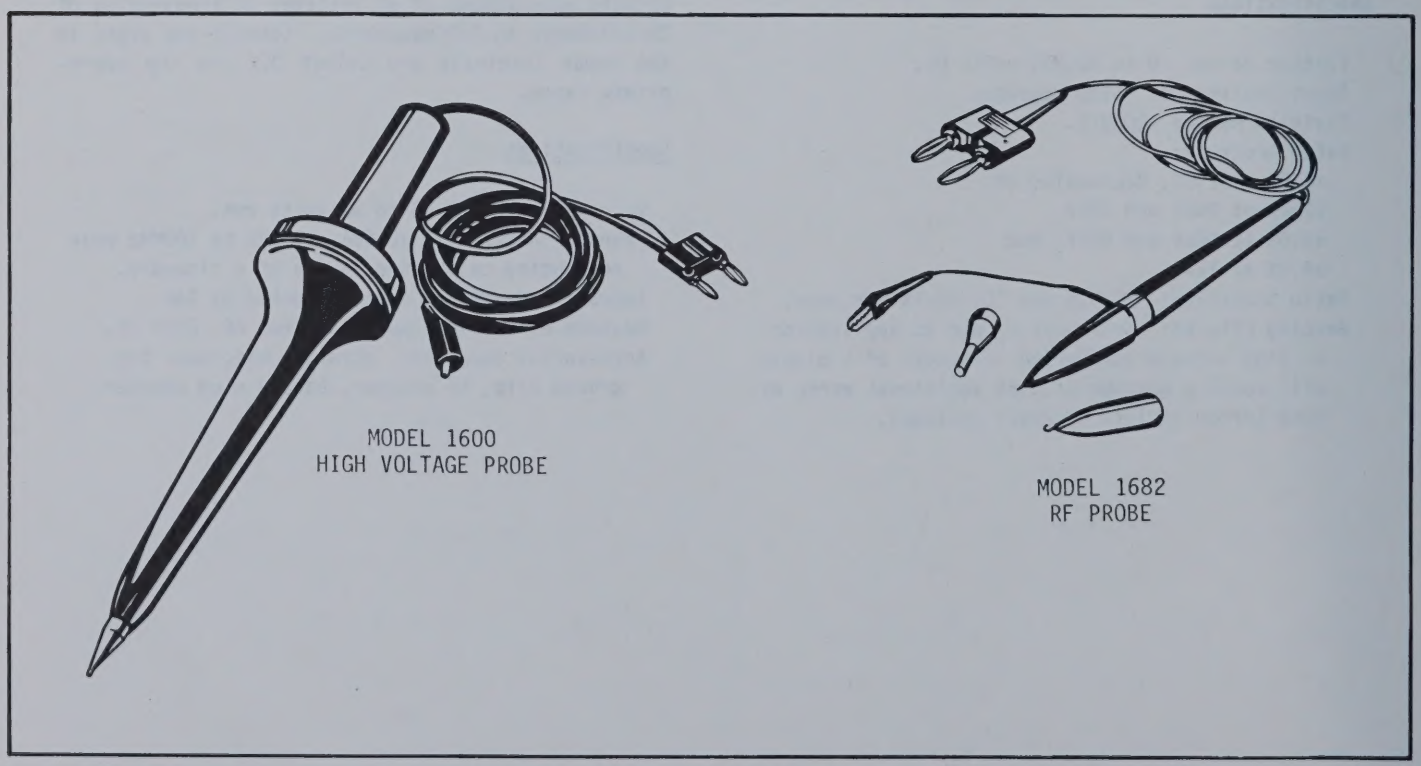
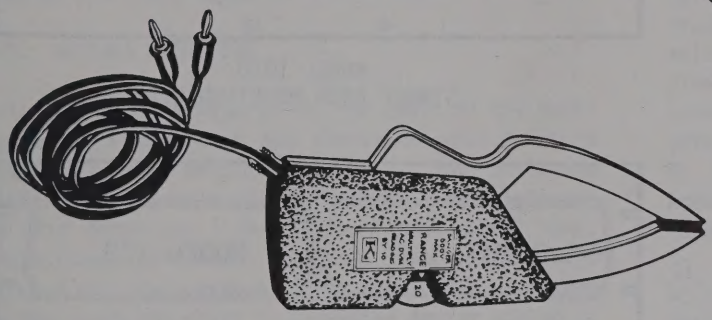
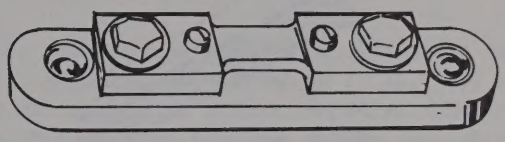


FIGURE 4-1. High Voltage Probe and RF Probe.



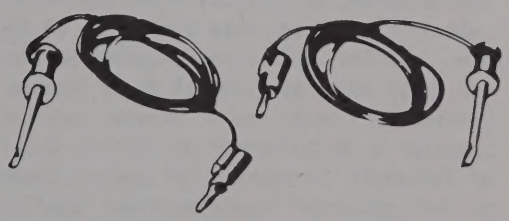
MODEL 1685
CLAMP-ON AC CURRENT PROBE

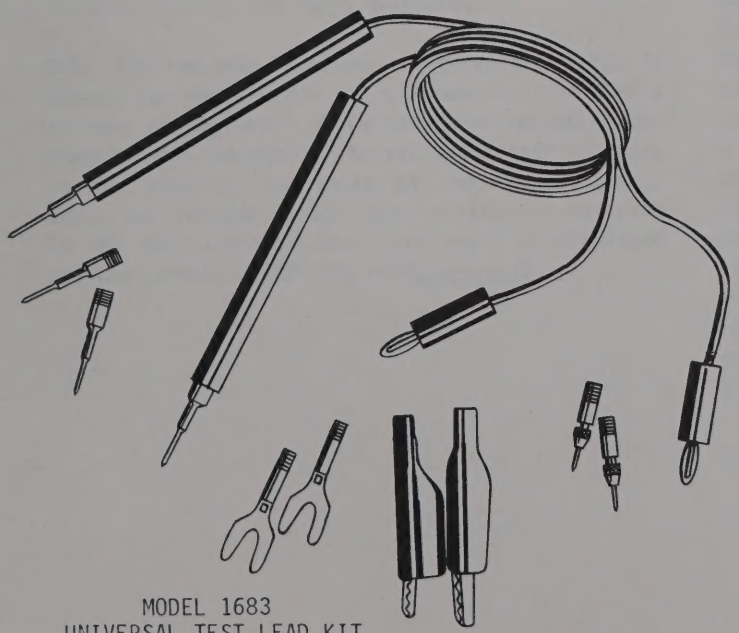


MODEL 1651
50-AMPERE SHUNT

FIGURE 4-2. Current Probe and Current Shunt.

MODEL 1681
CLIP-ON TEST LEAD SET





MODEL 1683
UNIVERSAL TEST LEAD KIT

MODEL 1691
GENERAL PURPOSE TEST
LEAD SET

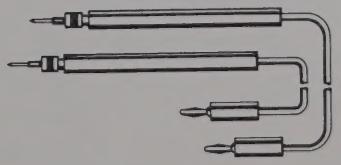


FIGURE 4-3. Convenience Cable and Connectors.

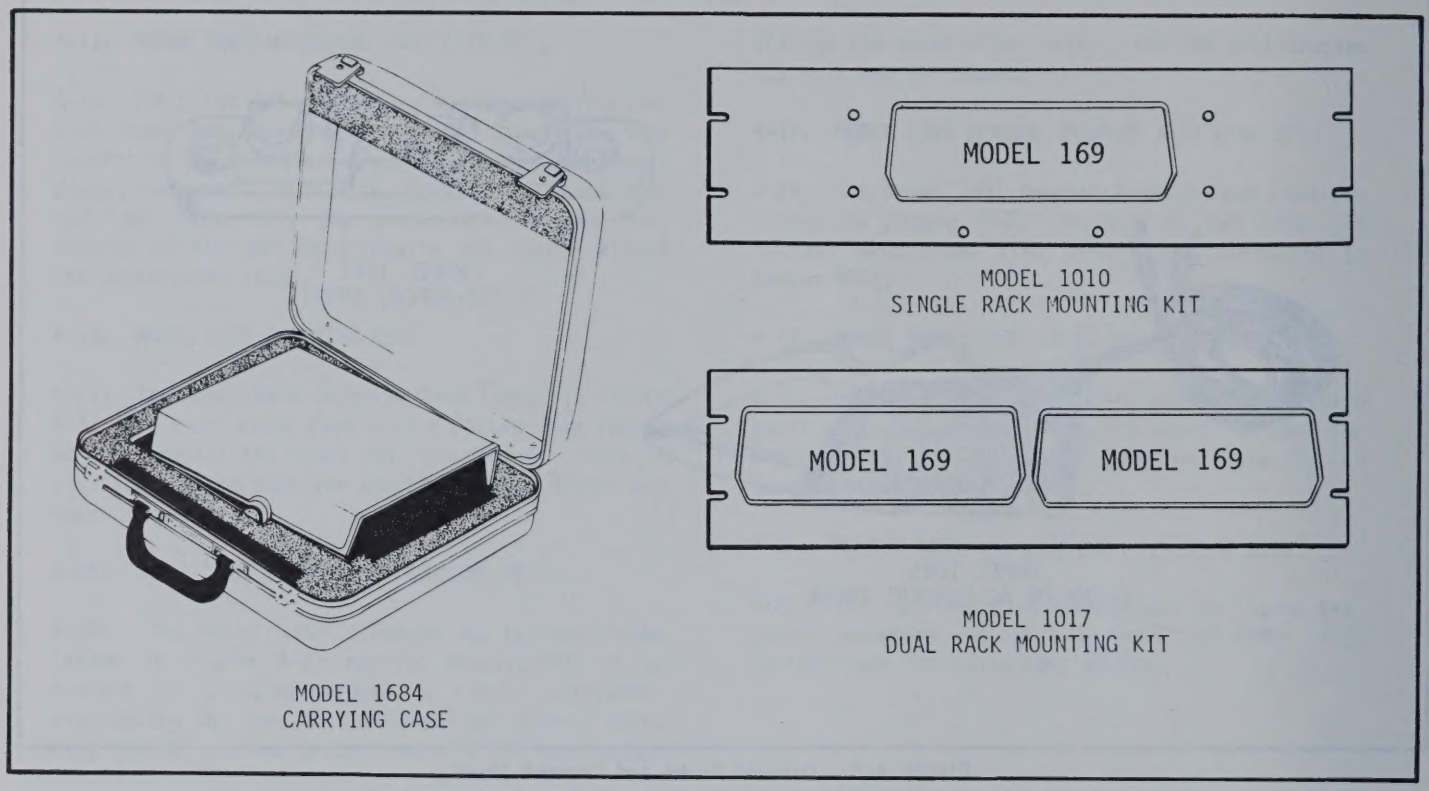


FIGURE 4-4. Carrying Case and Rack Mounting Kits.

SECTION 5. THEORY OF OPERATION

5-1. GENERAL.

5-2. This section contains circuit descriptions for the Model 169 DMM. An overall block diagram of signal flow is provided in Figure 5-1. The overall schematic diagram, drawing 30180D, is contained in Section 7 of this manual.

5-3. OVERALL OPERATION.

5-4. As shown in Figure 5-1, the heart of the Model 169 is a single chip A/D converter with built-in liquid crystal display drivers. The displayed reading is the ratio of two floating input voltages to this converter. On all functions except ohms, one voltage (Reference) is 100mV. The other voltage (V_{INHI}) is the unknown input current or voltage to the Model 169 which is converted and/or scaled by the input signal conditioning circuitry to a dc voltage between zero and ±200mV. The displayed reading is then determined by the formula: 1000 ($V_{INHI} \div V_{REFERENCE}$). The A/D converter also automatically determines the polarity of the input signal and detects whether an overrange condition exists (>1999 counts). A minus sign is displayed, plus is implied, and an overrange is displayed by a 1 with the last three digits blanked. The annunciators are displayed by the combination of range and function switching, and the decimal point is positioned by the range switching.

5-5. For the ohms function, a reference resistor is placed in series with the unknown resistor and a voltage is applied. Since the same current flows through both resistors, the ratio of their voltages is the same as the ratio of their resistances. Thus, the voltage across each resistor is measured by the A/D converter and their ratio is displayed per the formula: 1000 ($VR_X \div VR_{REFERENCE}$).

5-6. SIGNAL CONDITIONING.

5-7. AC/DC Voltage Measurements.

5-8. For voltage measurements, as shown in Figure 5-2, the input is divided by 1, 10, 100, 1000, or 10,000 by the 10 megohm resistive divider. The resulting output from the divider is a 0 to 200mV voltage. For a dc input, this voltage is applied direct to the A/D converter along with the 100mV reference. It should be noted that, since no active gain or attenuator stages are used, the dc accuracy is determined primarily by the precision resistor accuracies (actually their ratios) and the reference adjustment.

5-9. For an ac input, the output of the resistive divider is first applied to the AC Converter. The AC converter is a half wave rectifier with 100µV resolution and sufficient gain to provide a positive dc output voltage equivalent to the rms value of a sinusoidal input. Thus, for sinusoidal input of 100mVac, the output will be 100mVdc. The important gain determining elements of the converter are precision resistors so that a gain adjustment is not required.

5-10. AC/DC Current Measurement.

5-11. For current measurements, as shown in Figure 5-3, the appropriate shunt resistor is placed across the DMM input in accordance with the selected range. As with voltage measurements, the voltage drop across the current shunt is designed to be 200mV for a full scale input current on any range. Therefore, after the input current is converted to a voltage, the measurement process for current is identical to that for voltage measurements. Accuracy for dc current measurements is primarily determined by the accuracies of the precision shunt resistors and the reference adjustment. These two items also affect ac accuracy along with any error contributed by the AC Converter.

5-12. Resistance Measurements.

5-13. Resistance measurements are made by comparing the voltage drop across the unknown resistance to the voltage drop of an internal reference resistor as shown in Figure 5-4. For this ratio measurement technique, a voltage is connected to the input divider used for voltage measurements and the range switching selects a 1/2 of full scale value reference resistance to be placed in series with the unknown resistor. The voltage drops are then compared by the A/D converter and displayed on the LCD. A 2 kilohm thermistor (RT101) provides overvoltage input protection for the low resistance ranges and it is in series with the reference resistor and the unknown resistor on all but the 20 megohm range. For this reason, the +V (+2.8V nominal) top of the reference is selected on the 200 ohm range. On all other ranges +1.2V is used. Since a ratio technique is used, actual values of the reference resistors determine the primary accuracy for resistance measurements, and no adjustments are necessary.

5-14. A/D CONVERTER.

5-15. As shown in Schematic 30180D, the A/D converter and display drivers are contained on a single integrated circuit (U102). This chip also contains an oscillator and the regulators that are used to establish the analog and digital grounds. External components are used to establish the timing and reference levels required for A/D operation. U102 employs the dual slope principle of A/D conversion. This method provides a measurement cycle consisting of three consecutive time periods, autozero, signal integrate and reference integrate (read). Timing for these periods, and thus the measurement period, is a function of the oscillator frequency. The oscillator components are selected to provide 40 kHz which results in a 100 millisecond signal integrate period for best rejection of 50Hz and 60Hz. To begin each measurement cycle, the autozero period is set to a minimum of 100 milliseconds. During this period, the reference voltage input to the A/D is stored on capacitor C111 and the A/D converter is referenced to analog common. A correction voltage is then stored on capacitor C102 for use during the remainder of the measurement cycle, if any amplifier offset exists. The second phase of the measurement cycle is the 100mS signal integration period as previously mentioned. During this period, the differential voltage between IN HI and IN LO is integrated. At the end of this period, the polarity of the integrated signal is also determined. The final phase is reference integrate, or read. During this period, internal circuitry ensures that the reference capacitor will be connected with the correct polarity to return the integrator output to the autozero level. The time required for the output to return to this level is proportional to the unknown input signal. The read period can be from zero to 200 milliseconds, corresponding to displayed counts of zero to 2000 full scale as determined by 1000 ($V_{IN} \div V_{REF}$). For input signals less than full scale, the A/D converter reverts to autozero for the remainder of the reference integrate period. Thus, a complete measurement cycle is 400ms, which results in a display update rate of 2-1/2 per second.

5-16. DISPLAY CIRCUITS.

5-17. The liquid crystal display (LCD) and its associated circuitry is shown in Schematic 30180D. As previously mentioned, the seven segment decoders and drivers are provided by the A/D converter chip U102. The digitized measurement data is presented on the output lines to the LCD. These lines are driven by a square wave having the same amplitude and frequency as the BACKPLANE line (nominally 0 to +5V at 50Hz). When the lines to the display segments are driven out of phase with BACKPLANE the segments are ON. Conversely, when in-phase the segments are OFF. The annunciators and decimal points are turned ON and OFF similarly, with the phasing of their lines controlled by the range and function switches through logic gates. A summary of annunciator switching is given in Table 5-1.

5-18. REFERENCE SOURCE.

5-19. The reference source supplies 100mV (regulated and calibrated) to the A/D converter for voltage and current measurements. It also provides approximately 2.8V to the 200Ω range and approximately 1.2V to all other Ω ranges during resistance measurements. The heart of the reference source is a band-gap reference (VR101) that regulates the voltage to a value between 1.20 and 1.25 volts at approximately 500μA. Recall that the voltage applied to the reference source depends on the internal regulator in the A/D converter which establishes analog ground nominally 2.8 volts below V+. Thus, the value of R102G is selected to provide a minimum current of 400μA to VR101 to ensure a good temperature coefficient. R101 provides the calibration adjustment, while R102D and R102E limit the adjustment span and are stable precision resistors to ensure the 1 year calibration cycle.

5-20. LOW BATTERY DETECTOR.

5-21. The low battery detector is a simple transistor switch (Q102) which compares the negative supply to digital common (ground). Q102 is set for a nominal supply voltage of 6.9 volts. (Actual battery voltage will be about 7.2 volts due to the drop of CR105.) In the Model 169, the primary limit to battery usefulness is the integrator swing on the high ohms ranges with a full scale input. For this reason, the low battery indicator (BAT) should turn on with a battery voltage of 6.5 volts, or above, for the proper functioning of the A/D Converter and the low battery indicator.

5-22. INPUT PROTECTION.

5-23. Effective input protection circuitry has been designed into the Model 169 which provides protection against accidental input overloads on all functions and ranges. This circuitry is described in the following paragraphs for each function.

5-24. Voltage Protection.

5-25. R107 and R103 protect the A/D converter during dc voltage measurements by limiting the current to ±1mA.

5-26. For ac voltage measurements, U101 is protected by using R107 for current limiting and CR103 and CR104 to clamp the voltage to digital common and V+. Overload currents are returned to analog common through C107, C113 and the A/D converter.

5-27. Current Protection.

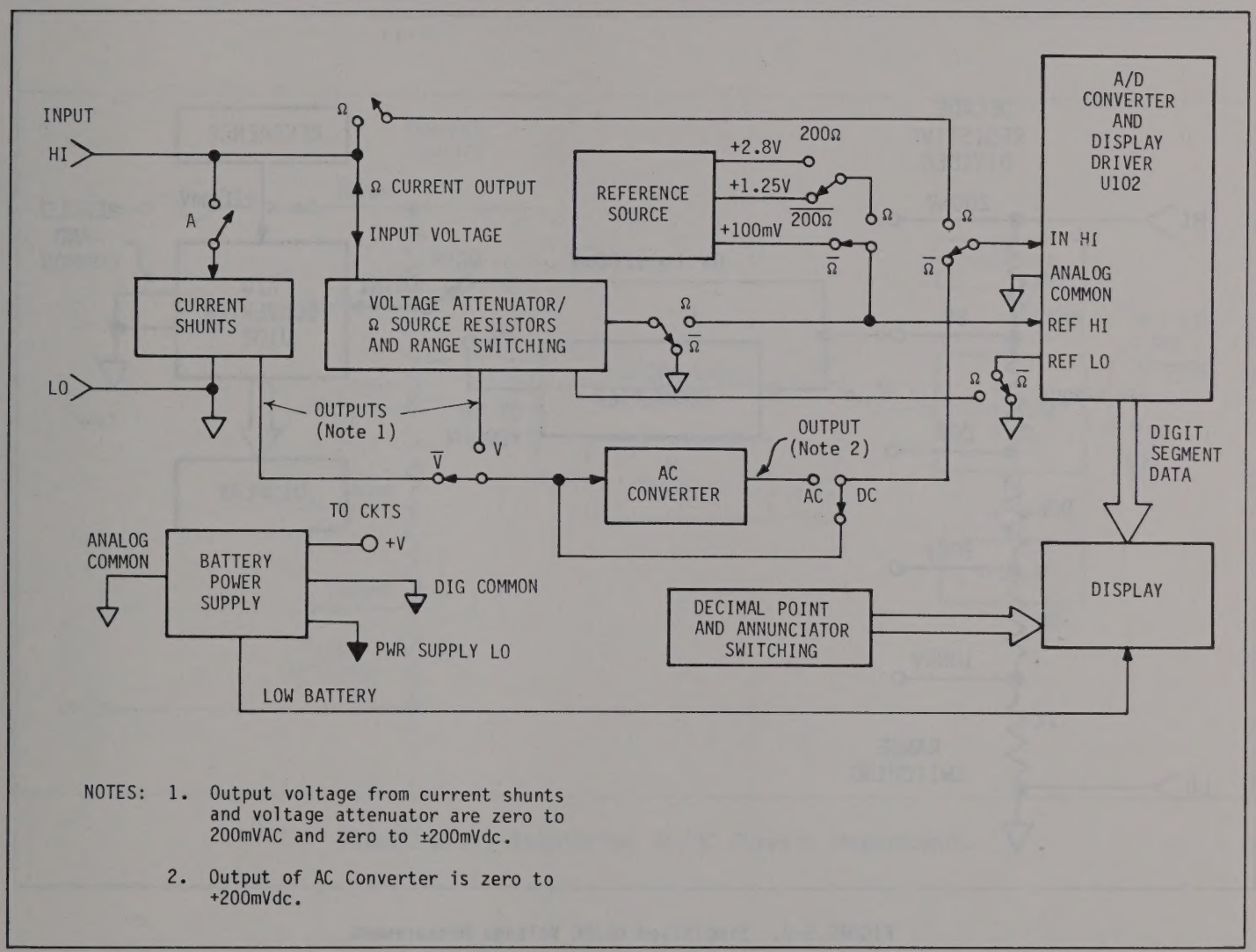
5-28. On the higher current ranges, F101 (2A, 250V) opens for input current overloads with up to 250 volts. On the lower current ranges, CR106 and CR107 clamp the input voltage to about 1 volt until F101 opens.

5-29. Ohms Protection.

5-30. Transistor Q101 and thermistor RT101 are the basic components used to provide protection during resistance measurements. Q101 is used as a low leakage zener to clamp any unintentially applied voltage to ground. RT101 is a positive temperature coefficient thermistor which bears the applied voltage by increasing its resistance. This limits current to protect Q101. R103 is used to protect IN HI of the A/D converter as in DC volts. Since the voltage across Q101 can be 10 volts above the positive supply, R102C protects REF LO and R106E protects REF HI by limiting the current to +100μA. Since VR101 has a current limit of 10mA, it is protected by R102G on the 200Ω range and by R102F plus the divider resistance on the other ranges. For negative input overloads the circuit operates the same, except Q101 is then forward biased and clamps to ANALOG COMMON.

TABLE 5-1
Annunciator Truth Table

ANNUNCIATOR	SWITCH	CONDITION
BAT	Q102	OFF
AC	DC/AC	AC
	Ω	OFF
DP1	2K	ON
DP2	20K or 20M	ON
DP3	200 or 200K	ON
V	V	ON
Ω	Ω	ON
k	200 and 20M	OFF
	Ω	ON
M	20M	ON
A	A	ON
μ	A and 200	ON
m	1. A	ON
	200	OFF
	2. V and 200	ON



NOTES:
1. Output voltage from current shunts and voltage attenuator are zero to 200mVAC and zero to ±200mVdc.
2. Output of AC Converter is zero to +200mVdc.

FIGURE 5-1. Model 169 DMM Overall Signal Flow Block Diagram.

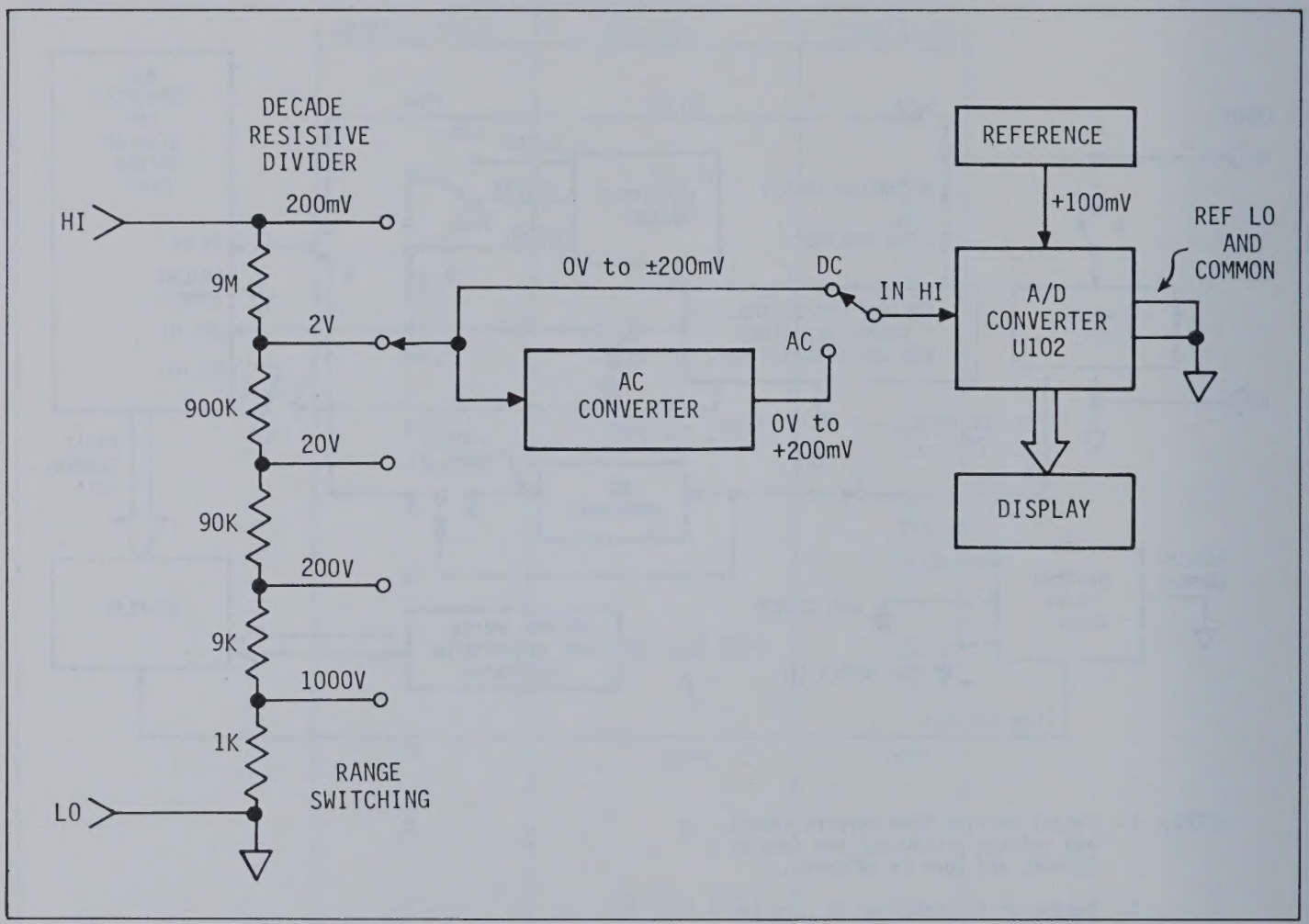


FIGURE 5-2. Simplified AC/DC Voltage Measurement.

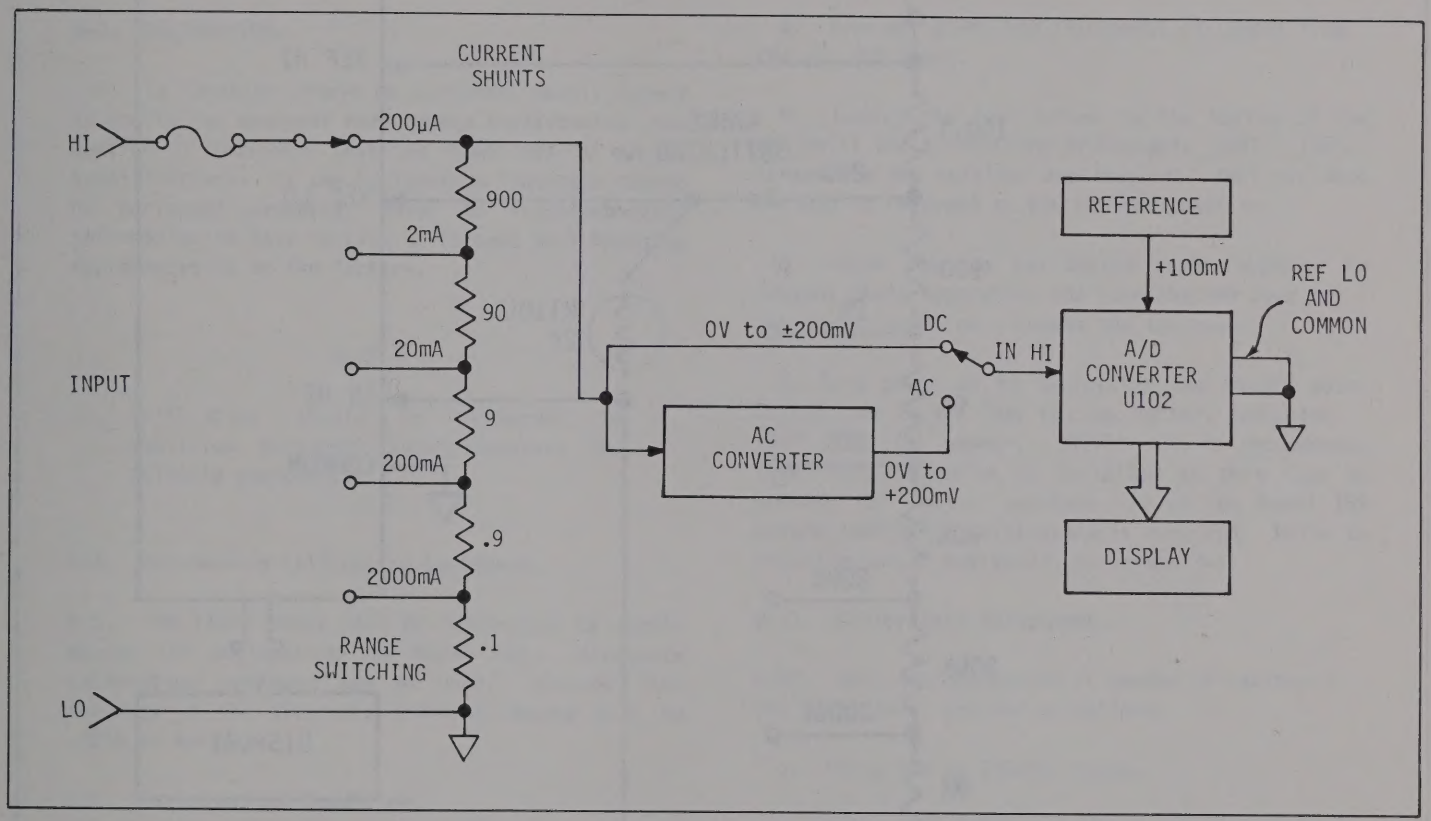


FIGURE 5-3. Simplified AC/DC Current Meaurement.

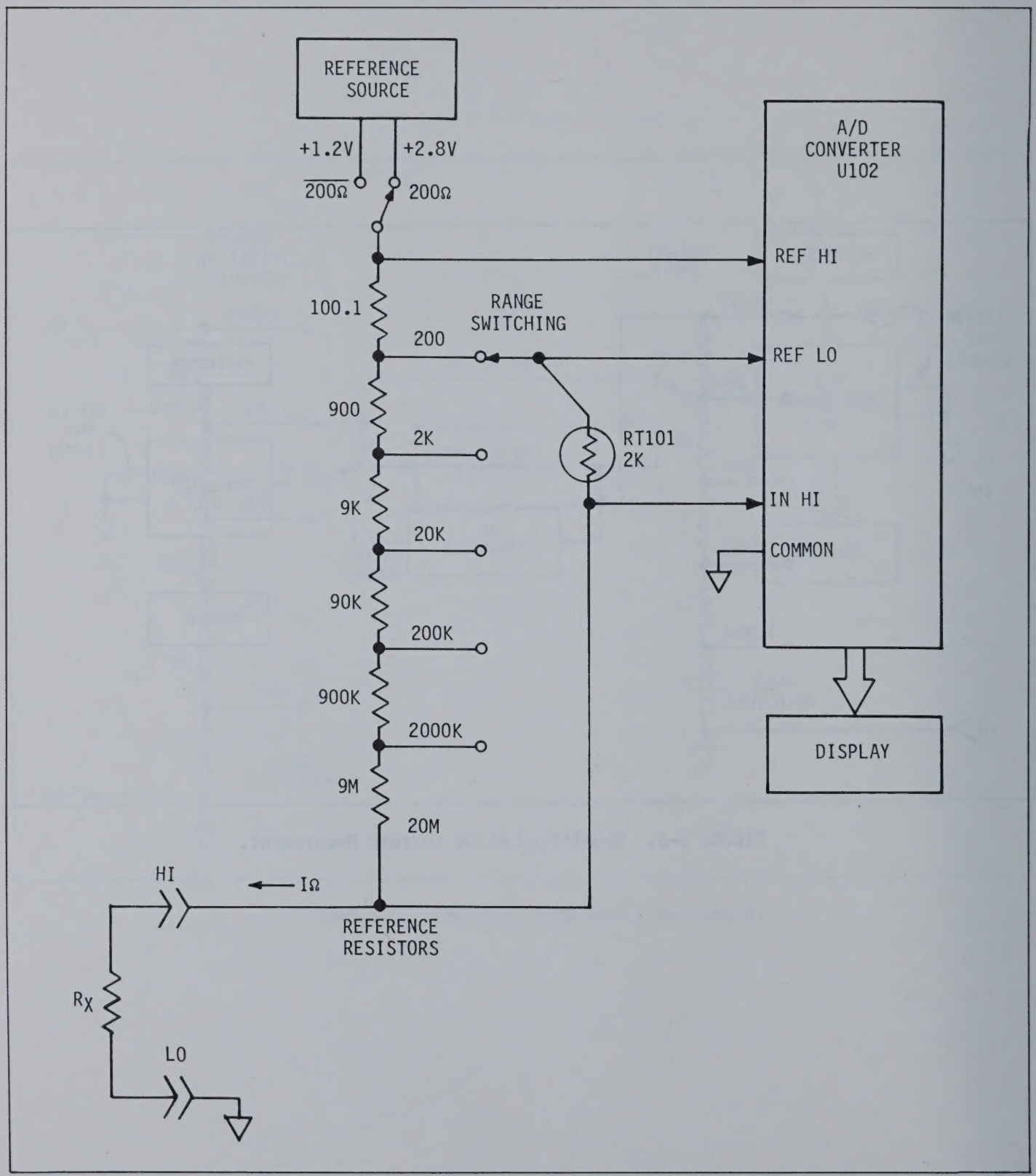


FIGURE 5-4. Simplified Resistance Measurement.

SECTION 6. MAINTENANCE

6-1. GENERAL.

6-2. This section contains information necessary to maintain the Model 169 DMM. Adjustment/calibration, troubleshooting, battery replacement, fuse replacement and LCD replacement procedures are provided.

6-3. CALIBRATION.

6-4. Calibration should be performed yearly (every 12 months) or whenever Performance Verification (see Section 3) indicates that the Model 169 is out of specifications. If the Calibration Procedure cannot be performed properly, refer to Troubleshooting information in this section or contact your Keithley representative or the factory.

NOTE

Calibration should be performed by qualified personnel using accurate and reliable equipment.

6-5. Recommended Calibration Equipment.

6-6. The Fluke Model 341A DC Calibrator is recommended for calibrating the Model 169. Alternate calibration equipment may be used. However, the accuracy of the alternate 190 mVDC source must be .025% or better.

6-7. Environmental Conditions.

6-8. Calibration should be performed under environmental conditions having an ambient temperature of 23° ±2°C and a relative humidity less than 70%. If the Model 169 has been exposed to extremes of temperature or humidity, allow at least one hour for the instrument to stabilize.

6-9. Case Cover Removal.

6-10. To gain access to the calibration pot and circuit components, remove the case cover as follows:

WARNING

Disconnect all test circuits from the INPUT connections of the Model 169 before removing the case cover.

a. Turn off power and disconnect all leads from the 169 DMM input.

b. Loosen the four screws in the bottom of the DMM until the threads are disengaged. NOTE: These screws are not retained and they will fall out when the DMM is returned to the upright position.

c. Hold the top and bottom cover together to prevent their separation and turn the DMM over to its normal position. Remove the top cover.

d. Turn power on by depressing the ON/OFF pushbutton, and verify that the low battery indicator (BAT) does not appear. (NOTE: It is recommended that fresh batteries be installed at this time to provide the longest possible use of the Model 169 before additional maintenance is required. Refer to Installation of Batteries, Paragraph 2-6).

6-11. Calibration Adjustment.

6-12. Only one adjustment is needed to calibrate the Model 169. Proceed as follows:

a. Place 169 on 200mVDC range.

b. Apply -190.0mVDC and adjust R101 (see Figure 6-1) for a reading of -190.0.

c. Apply +190.0mVDC and note reading.

d. Adjust R101 for a reading half way between noted reading and 190.0 (e.g. if noted reading is 190.2, adjust R101 for a reading of 190.1).

6-13. This completes calibration of the Model 169. Reinstall the DMM top cover and verify performance as outlined in Section 3.

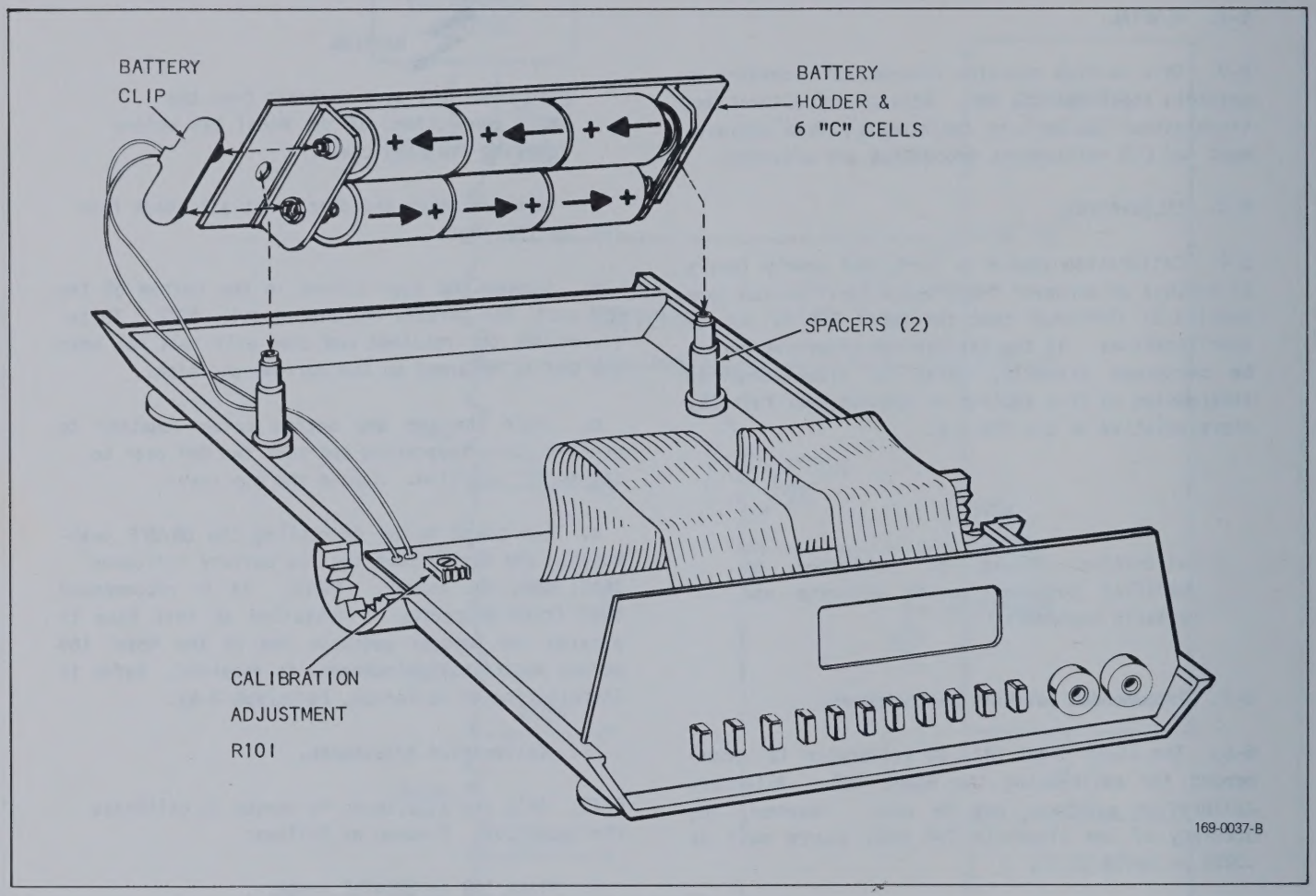


FIGURE 6-1. Calibration Adjustment Location.

6-14. TROUBLESHOOTING.

6-15. The following troubleshooting instructions are intended for qualified personnel having a basic understanding of analog and digital electronic principles and components used in a precision electronic test instrument. Instructions have been written to assist in isolating the defective circuit or subcircuit. Isolation of the specific defective component has been left to the technician. Remove the case cover as explained in Paragraph 6-9 to gain access to circuit components and test point locations.

6-16. Special Handling of Static Sensitive Devices.

6-17. CMOS devices are designed to function at very high impedance levels for low power consumption. For this reason, a normal static charge build up on your person or clothing can be sufficient to destroy these devices. The following steps list the static sensitive devices in your Model 169 and provide instruction on how to avoid damaging them when they must be removed/replaced.

a. Static sensitive devices:

Keithley Part Number	Reference Designation
LSI-22	U102
IC-102	U103
IC-226	U104, U105
IC-228	U106
DZ-62	VR101

b. The above integrated circuits should be handled and transported only in protective containers. Typically they will be received in metal tubes or static protective foam. Keep the devices in their original containers until ready for use.

c. Remove the devices from their protective containers only at a properly grounded work bench or table, and only after grounding yourself by using a wrist strap.

d. Handle the devices only by the body. Do not touch the pins.

e. Any printed circuit board into which a device is to be inserted must also be grounded to the bench or table.

f. Use only anti-static type solder suckers.

g. Use only grounded tip soldering irons.

h. After soldering the device into the board, or properly inserting it into the mating receptacle, the device is adequately protected and normal handling can be resumed.

6-18. Power Supply.

6-19. In general, start troubleshooting with Table 6-1, Power Supply Checks, to verify that the battery and power supply are providing the correct voltages to the electronic components. If it is determined that the battery needs replacing, refer to Paragraph 6-33, Battery Replacement.

6-20. A/D Converter and Display Driver.

6-21. Proper operation of the A/D Converter and Display Driver circuit should be verified before troubleshooting the signal conditioning circuits. Check these circuits per Tables 6-2 and 6-3. If it is determined that the Liquid Crystal Display is defective, replace per instructions in Paragraph 6-31.

6-22. AC Converter.

6-23. Problems with ac voltage may involve the AC Converter circuitry. Check this circuit per Table 6-4.

6-24. Voltage Divider, Reference Source and Ohms Circuit.

6-25. Problems with voltage or resistance ranges may involve these signal conditioning circuits. Check out the Reference Source and Ohms Circuit per Tables 6-5 and 6-6. The Voltage Divider can be checked by measuring the resistance of each resistor individually with the instrument off and the push-buttons in the out position. The tolerances of the Voltage Divider resistors are as follows:

a. R108, 100.1Ω, 0.1%

b. R109, 900Ω, 0.1%

c. R110, 9KΩ, 0.1%

d. R111, 90KΩ, 0.1%

e. R112, 900KΩ, 0.1%

f. R113, 9MΩ, 0.08%

6-26. Current Circuitry.

6-27. If problems occur with current readings, check the current circuitry as directed in the following paragraphs. It should be noted that, since the current shunts are common to both ac and dc current, problems should exist on the same ac and dc current ranges if there is a fault in the current shunt circuitry.

6-28. The current fuse can be checked out by simultaneously depressing the A and Ω pushbuttons while on the 2K range. The display reading for a good fuse is nominally .100mAKΩ. A blown fuse will be indicated by an overranged display. If the current fuse is blown, replace per instructions in Paragraph 6-35.

6-29. The Current Shunts can be checked by measuring the resistance of each resistor individually with the instrument off and all the pushbuttons in the out position. The tolerances of the shunts are as follows:

a. R114A, 0.9Ω, 0.5%

b. R114B, 0.1Ω, 0.5%

c. R115, 9Ω, 0.5%

d. R116, 90Ω, 0.1%

e. R117, 900Ω, 0.1%

6-30. Check the current protection diodes (CR107 and CR108) as follows:

a. Select 200μADC range.

b. Apply 5VAC through a 1KΩ current limiting resistor to the input of the Model 169.

c. Clamping across the diodes must occur at ±1V or less.

6-31. LIQUID CRYSTAL DISPLAY REPLACEMENT.

6-32. Perform the following procedure, referring to Figure 6-4, to replace the display of the Model 169.

a. Remove the case cover as explained in Paragraph 6-9.

b. Remove the three 3/8" pal nuts holding PC-509 to the front panel.

c. Separate PC-509 from the front panel being careful of the LCD display (Keithley Part No. 30347) as it will be loose and may fall out of the front panel.

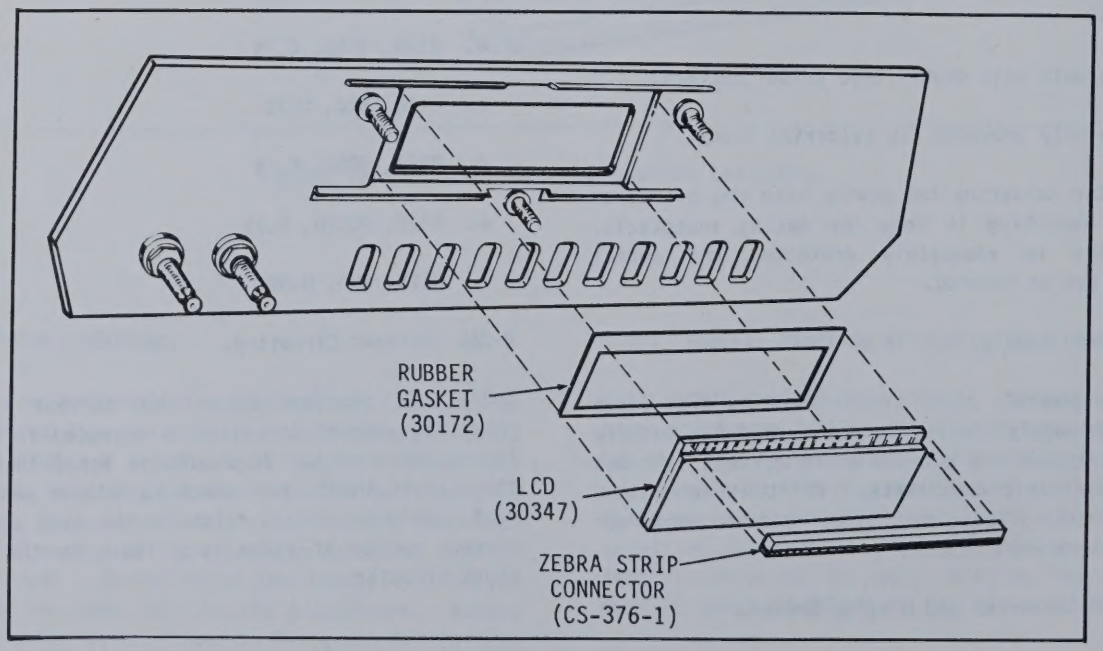


FIGURE 6-2. LCD Assembly.

TABLE 6-1
Power Supply Checks

STEP	ITEM/COMPONENT	REQUIRED CONDITION*	REMARKS
1	Battery Voltage	7.5V min.	
2	CR105	0.5V drop max.	
3	U102, pin 40 and 15	7.0V min.	Supply to U102
4	C107	2.4 to 3.2V	Output of U102 (Analog Gnd)
5	C113	0.8 to 2.6V	Output of U102 (Digital Gnd)
*Above checks with fresh batteries and power switch ON.			

TABLE 6-2
A/D Converter

STEP	ITEM/COMPONENT	REQUIRED CONDITIONS*	REMARKS
1		Power ON, 200mVDC Range	
2	Display	Short input, 00.0 ±1d	Zero Check
3	Reference (U102, pin 5)	Nominally 98mV using voltmeter with 10MΩ Input Impedance	High Impedance reference
4	Ratio Test	Short U102 pin 5 to pin 10	Connects reference to input
5	Display	100.0 ±2d	If steps 3 and 5 are correct A/D Converter is functioning properly
6	U106, Pin 3	40kHz ±6kHz** Approx. 5Vp-p	Clock check
7	External Voltage Source	Apply +190.0mVAC	Calibration point
8	U106 Pin 14 to Input Lo	See waveform (Figure 6-3)	Integrator Check
*Measurements made with respect to input lo **Non-symmetrical in most cases			

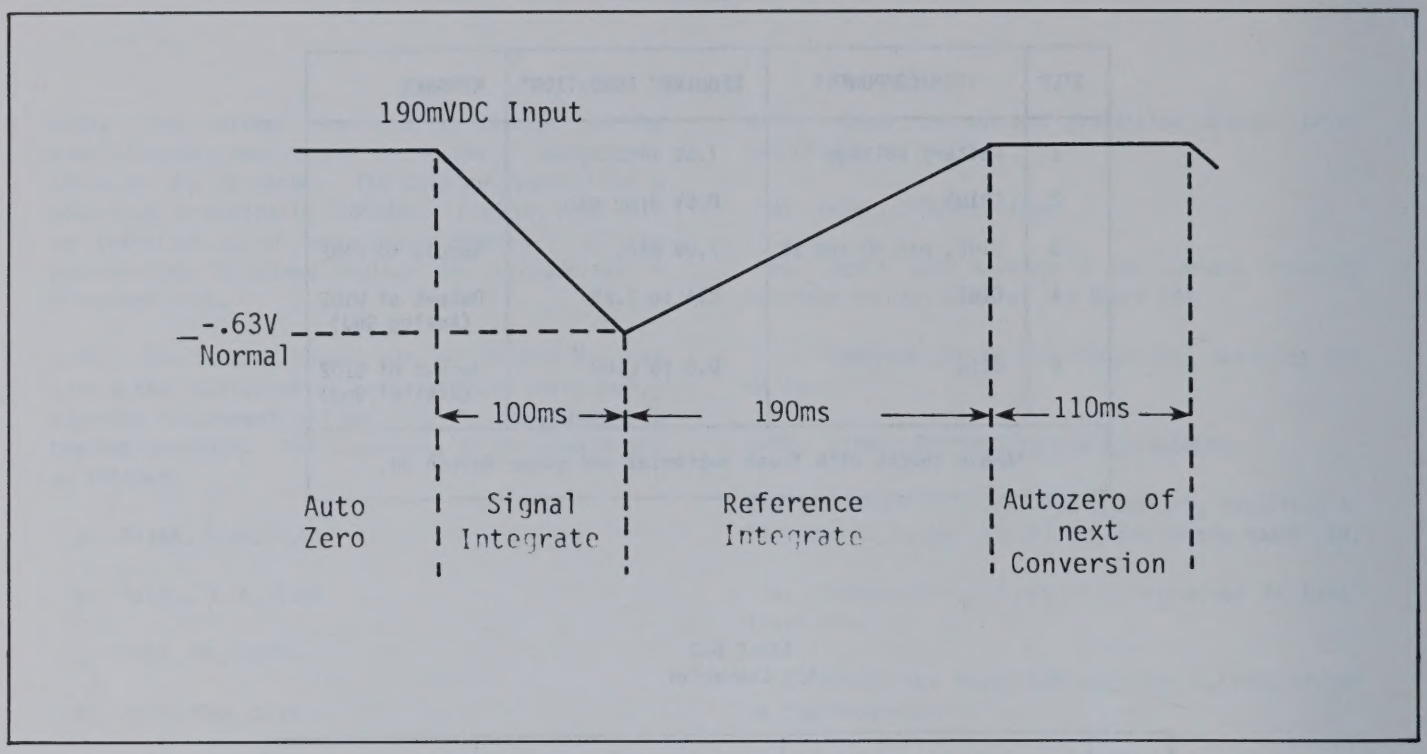


FIGURE 6-3. Integrator Waveform.

TABLE 6-3
Display Driver

STEP	ITEM/COMPONENT	REQUIRED CONDITIONS	REMARKS
1		Power ON	
2	U102 pin 40 to pin 4	4.0 to 6.0 Volts	Digital Supply
3	U102 pin 3 to Input Lo	40kHz ±6kHz Approx. 5Vp-p	Clock Check
4	U102 pin 20 to Input Lo	Approx. 50Hz Square wave, approx. 5Vp-p	
5	U102 - any display driver line	Approx. 50Hz Square wave, approx. 5Vp-p	In phase with backplane for segment off, Out of phase with backplane for segment on
6	U104, U105, U106, decimal point and annunciator driver lines	Approx. 50Hz square wave, approx. 5Vp-p	

TABLE 6-4
AC Converter

STEP	ITEM/COMPONENT	REQUIRED CONDITIONS	REMARKS
1		Power ON, 200mVAC Range	
2	U101 pin 7 to pin 4	7V min.	Supply Voltage
3	External Voltage Source	Apply 100mVAC at 100Hz	Calibrated Input
4	C108	98mVDC Nominal using 10MΩ input impedance voltmeter	High Impedance DC output
5	U101 pin 6 to Input Lo	See Waveform (Figure 6-4)	
6		Short Input	
7	U101 pin 6 to Input Lo	±5mVDC offset max.	

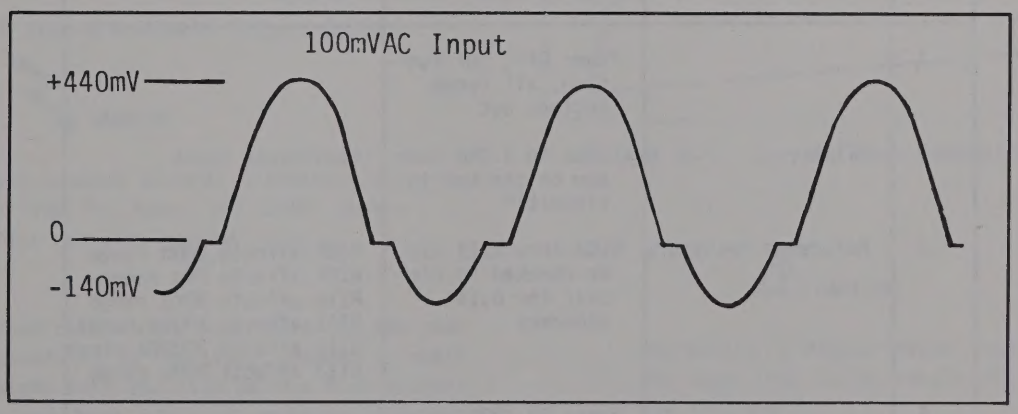


FIGURE 6-4. AC/DC Converter Waveform.

TABLE 6-5
Reference Source

STEP	ITEM/COMPONENT	REQUIRED CONDITIONS	REMARKS
1		Power ON	
2	U102 pin 40 to Input Lo	2.4 to 3.2 VDC	Output of U102 (Analog Supply)
3	VR101 (<100pf probe)	1.2 to 1.25V	Reference Source
4	R102 pin 8 to Input Lo	Nominally 100mVDC using voltmeter with ≥10MΩ input impedance	

TABLE 6-6
Ohms Circuit

STEP	ITEM/COMPONENT	REQUIRED CONDITIONS*	REMARKS
1		Power OFF, DCV function, all range buttons out	
2	RT101	1.0KΩ to 3.0KΩ (can now be checked in circuit)*	Resistance Check
3	Reference Resistors	R108 thru R113 can be checked in circuit for 0.1% accuracy	R108 affects 200Ω range R109 affects 2KΩ range R110 affects 20KΩ range R111 affects 200KΩ range R112 affects 2000KΩ range R113 affects 20MΩ range
4		Power ON, 200Ω range, Input open	
5	Q101	>2 Volts across emmitter - collector junction	Voltage drop check

*Do not remove RT101 unless absolutely necessary because the leads fall off device easily while soldering.

d. Make sure the rubber gasket is in place before placing the new display in the slot of the front panel.

e. The zebra strip should be installed after the new display is placed in the front panel window. Care must be taken to assure the zebra strip is kept clean. The zebra strip should be aligned such that the black stripes contact the conductors on the display and the conductors on PC-509.

f. Reassemble PC-509 and the front panel using the three 3/8" pal nuts. Tighten them until they are snug.

g. Turn the unit "ON" and check the display to see that it is working properly. If the zebra strip is not aligned properly or if it is dirty there will be some segments on the display that will not light.

6-33. BATTERY REPLACEMENT.

6-34. The low battery indicator will automatically come on with approximately 5% of battery life remaining (20 hours for carbon-zinc and 40 hours for alkaline cells). Replace per directions in Paragraph 2-6.

6-35. CURRENT FUSE REPLACEMENT (Figure 6-5).

WARNING

To prevent a shock hazard, disconnect all circuits from the Model 169 INPUT terminals before removing current fuse.

6-36. To remove the current fuse, turn the DMM over and lay it carefully on its top. Insert a small screwdriver blade into the slot on the fuse holder, press gently and turn 1/4-turn counter-clockwise. Lift the holder and fuse out of the receptacle. The fuse can now be removed for checking or replacement. Replace with one of the following types:

a. U.S.A. Use - 3AG, 250V, 2A, Normal Blow

b. Europe Use - 5 x 20mm, 250V, 2A, Normal Blow

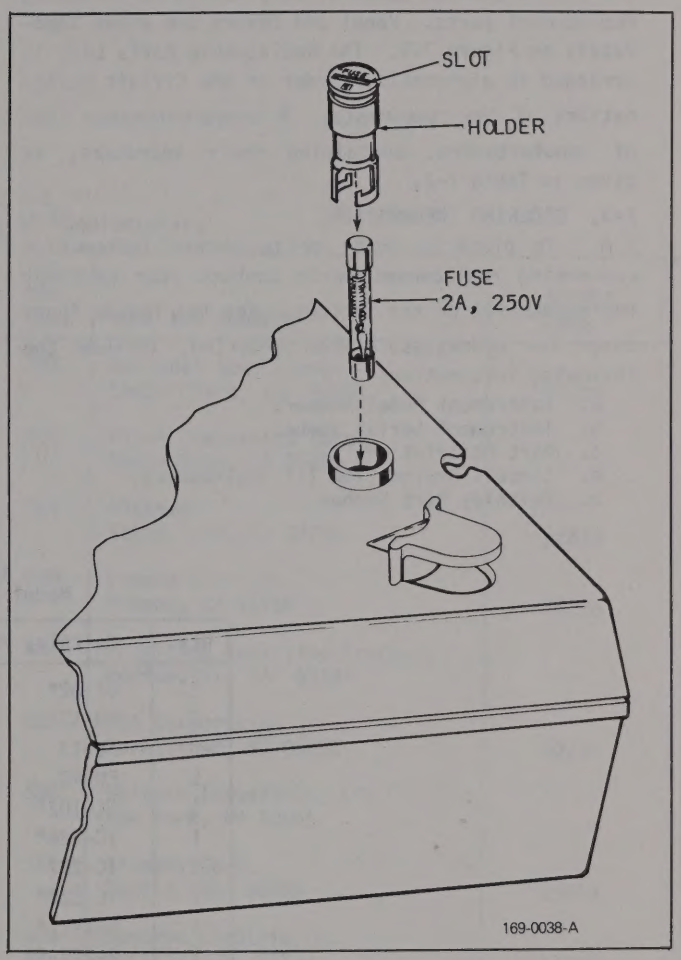


FIGURE 6-5. Current Fuse Removal/Replacement.

CAUTION

Installing a higher rated fuse than the one specified could result in damage to the instrument.

SECTION 7. REPLACEABLE PARTS.

7-1. GENERAL.

7-2. This section contains information for ordering replacement parts. Panel and covers are shown separately on Figure 7-1. The Replaceable Parts List is arranged in alphabetical order of the Circuit Designations of the components. A cross-reference list of manufacturers, containing their addresses, is given in Table 7-2.

7-3. ORDERING INFORMATION.

7-4. To place an order or to obtain information concerning replacement parts contact your Keithley representative or the factory. See the inside front cover for addresses. When ordering, include the following information:

a. Instrument Model Number.
b. Instrument Serial Number.
c. Part Description.
d. Circuit Designation (if applicable).
e. Keithley Part Number.

7-5. FACTORY SERVICE.

7-6. If the instrument is to be returned to the factory for service, please complete the Service Form which follows this section, and return it with the instrument.

7-7. SCHEMATIC.

7-8. The Model 169 3-1/2 Digit DMM: Schematic No. 30180D (Page 7-5).

7-9. COMPONENT LAYOUT.

7-10. Model 169 PC-508, Component Layout No. 30176D (Page 7-6).

7-11. MODEL 1699 SPARE PARTS KIT.

7-12. A spare parts kit is available that contains a complement of spare parts that can maintain up to ten Model 169's for approximately one year. A list of the spare parts is given in Table 7-1.

TABLE 7-1
Model 1699 Parts List

Qty.	Keithley P/N	Schematic Designation
2	DZ-62*	VR101
2	FH-12	Fuse holder
5	FU-13	F101 (3AG)
5	FU-48	F101 (5mm x 20mm)
1	IC-102*	U103
1	IC-226*	U104, U105
2	IC-227	U101
1	IC-228*	U106
1	LSI-22*	U102
1	R-277-9M	R113
3	RF-28	CR101 thru CR104
2	RF-34	CR106, CR107
1	RF-39	CR105
1	RT-5	RT101
3	TG-47	Q101, Q102

* Anti-Static Protection and Handling required. Refer to Section 6 of this Manual for Special Handling Procedures for Static-Sensitive Deivces.

TABLE 7-2
Cross Reference of Manufacturers

FED MFR. CODE	NAME AND ADDRESS	SUPPLY CODE	FED MFR. CODE	NAME AND ADDRESS	SUPPLY CODE
A-B	Allen-Bradley Corp. Milwaukee, WI 53204	01121	NAT	National Semi. Corp. Santa Clara, CA 95051	27014
BRN	Bourns, Inc. Riverside, CA 92507	80294	PCC	Panel Components Corp. Santa Rosa, CA 95401	
CAI	Callins Industries Greenfield, TN 38230	06643	PLY	Plessey Santa Anna, CA 92705	52648
CLB	Centralab Division Milwaukee, WI 53201	71590	POM	Pomona Electric Pomona, CA 91766	05276
CRS	Crystaloid Electronics Hudson, OH 44236		PRP	Precision Resistive Products Mediapolis, IA 53237	
D-E	Dale Electronics Columbus, NB 68601	91637	RCA	RCA Corporation Morristown, NJ 08050	02734
G-I	General Instrument Corp. Newark, NJ 07104	72699	SHG	Shigoto Industries, LTD New York, NY 10001	
INT	Intersil, Inc. Cupertino, CA 95014	32293	SIE	Siemens Corp. Iselin, NJ 08830	25088
ITT	ITT Components Lawrence, MA 08142	15238	SPG	Sprague Electric Co. Visalia, CA 93278	14659
K-I	Keithley Instruments, Inc. Cleveland, Ohio 44139	80164	T-I	Texas Instruments, Inc. Dallas, TX 75231	01295
L-F	Littlefuse, Inc. Des Plaines, IL 60016	75915	TKT	Tecknit Cranford, NJ 07016	
MCI	Midwest Components, Inc. Muskegon, MI 49443		UNC	Union Carbide New York, NY 10017	61637
MOT	Motorola Semi Products, Inc. Phoenix, AZ 85008	04713			

TABLE 7-3
REPLACEABLE PARTS LIST

Circuit Desig.	Description	Location Sch.	Location Pcb.	Mfr. Code	Mfr. Desig.	Keithley Part No.
BT101 thru BT106	Battery, 1.5V, "C" cell, Carbon Zinc	C6	---	UNC	Eveready 935	BA-6
C101	Cap, .1μF, 160V, Metalized Polypropylene	E2	B3	PLY	171/.1/J/160	C-306-.1
C102	Cap, .22μF 100V, Metalized Polyester	E2	B3	SIE	MKH-B-32560-.22/20/250	C-305-.22
C103	Cap, .047μF, 100V, Metalized Polyester	E1	B3	SIE	MKH-B-32560-.047/20/250	C-305-.047
C104	Cap, .1μF, 100V, Metalized Polyester	C2	B4	SIE	MKH-B-32560-.1/20/250	C-305-.1
C105	Cap, 4.7μF, 20V, Electrolytic Tantalum	C1	B4	CAI	SC-4.7-25-M	C-179-4.7
C106	Cap, .1μF, 100V, Metalized Polyester	C2	B4	SIE	MKH-B-32560-.1/20/250	C-305-.1
C107	Cap, 4.7μF, 20V, Electrolytic Tantalum	C5	B4	CAI	SC-4.7-25-M	C-179-4.7
C108	Cap, 1.5μF, 20V, Electrolytic Tantalum	D2	B4	ITT	TAPA-1.5-25-M	C-179-1.5
C109	Cap, .02μF, 1000V, Ceramic Disc	C1	B4	SPG	562Z-5UAA-102AM203M	C-298-.02
C110	Cap, 3.3pF, 1500V, Ceramic	A1	C4	SPG	10TCCV33	C-308-3.3P
C111	Cap, .047μF, 100V, Metalized Polyester	F1	D3	SIE	MKH-B-32560-.047/20/250	C-305-.047
C112	Cap, 110pF, 500V, Silver Mica	E2	D3	G-I	RDM-15FD-111F03	C-278-110P
C113	Cap, 4.7μF, 20V, Electrolytic Tantalum	C6	B3	CAI	SC-4.7-25-M	C-179-4.7
C114	Cap, .047μF, 100V, Metalized Polyester	D3	D3	SIE	MKH-B-32560-.047/20/250	C-305-.047
C115	Cap, 3600pF, 1000V, Ceramic Disc	B2,3	C4	CLB	DD-362	C-64-3600P
CR101	Rectifier, Silicon, 75mA, 75V	D2	A4	T-I	1N914	RF-28
CR102	Rectifier, Silicon, 75mA, 75V	D1	A4	T-I	1N914	RF-28
CR103	Rectifier, Silicon, 75mA, 75V	C1	B4	T-I	1N914	RF-28
CR104	Rectifier, Silicon, 75mA, 75V	C1	B4	T-I	1N914	RF-28
CR105	Rectifier, Germanium, 15mA, 25V	C6	A5	ITT	1N3592	RF-39
CR106	Rectifier, Silicon, 3A, 50V	A6	E4	MOT	MR-501	RF-34
CR107	Rectifier, Silicon, 3A, 50V	A6	E4	MOT	MR-501	RF-34

TABLE 7-3 (Cont'd)
REPLACEABLE PARTS LIST

Circuit Desig.	Description	Location Sch.	Location Pcb.	Mfr. Code	Mfr. Desig.	Keithley Part No.
DS101	Liquid Crystal Display	G3	---	CRS	SK 301-54H	DD-18
	Zebra Connector Strip	---	---	TKT	Z5-85 1010 Zebra	CS-376-2
F101	Fuse, 2A, 250V, 3AG (U. S. Models)	A4	---	L-F	312002	FU-13
F101	Fuse, 2A, 250V, 5 x 20mm (European Models)	A4	---	PCC	034.1519	FU-48
J1001	Banana Jack, Red	A1	---	POM	1581-2	BJ-11-2
J1002	Banana Jack, Black	A6	---	POM	1581-0	BJ-11-0
J1003	Battery Connector	C6	A2	SHG	YOS/1893/6A, SE-12	BH-28
Q101	Transistor, NPN	D3	B3	MOT	2N3904	TG-47
Q102	Transistor, NPN	D6	B3	MOT	2N3904	TG-47
R101	Potentiometer, 500Ω	C5	A3	BRN	3386F-1-501	RP-97-500
R102	Thick Film Resistor Network	Several	B3	K-I		TF-93
R103	Resistor, 1MΩ, 10%, 1W, Comp	E1	B3	A-B	GB-105-10%	R-2-1M
R104	Resistor, 10kΩ, .1%, 1/8W, MtF	D2	B3	PRP	*	R-179-10k
R105	Resistor, 4.72kΩ, .1%, 1/8W, MtF	D2	B3	PRP	*	R-179-4.72k
R106	Thick Film Resistor Network	Several	B4	K-I		TF-92
R107	Resistor, 100kΩ, 10%, 2W, Comp.	B1	B4	A-B	HB-104-10%	R-3-100k
R108	Resistor, 100.1Ω, .1%, 1/8W, MtF	B3	C4	PRP	*	R-179-100.1
R109	Resistor, 900Ω, .1%, 1/8W, MtF	B3	C4	PRP	*	R-179-900
R110	Resistor, 9kΩ, .1%, 1/8W, MtF	B2	C4	PRP	*	R-179-9k
R111	Resistor, 90kΩ, .1%, 1/8W, MtF	B2	C4	PRP	*	R-179-90k
R112	Resistor, 900kΩ, .1%, 1/2W, MtF	B2	D4	D-E	MFF-1/2-900k	R-135-900k
R113	Resistor, 9MΩ, .08%, 2W, CMtF	B1	D5	K-I		R-277-9M
R114	Resistor, Dual	B5,6	D5	K-I		R-278
R115	Resistor, 9Ω, .5%, 1/2W, MtF	B5	D4	D-E	MFF-1/2-9	R-61-9
R116	Resistor, 90Ω, .1%, 1/8W, MtF	B5	D4	PRP	*	R-179-90
R117	Resistor, 900Ω, .1%, 1/8W, MtF	B6	D4	PRP	*	R-179-900
RT101	Thermistor, 2kΩ, 40%, 8mA, 500V, PTC	B1	B4	MCI	180020200	RT-5
S101	Switch, 12 Station, Pushbutton	Several	C5	K-I	SW-416 $23.15	30314A

* Manufacturer's Designation is GP 1/4, 1%, T100, Resistance Value.

TABLE 7-3 (Cont'd)
REPLACEABLE PARTS LIST

Circuit Desig.	Description	Location Sch.	Location Pcb.	Mfr. Code	Mfr. Desig.	Keithley Part No.
U101	Low-Power JFET-Input OP-AMP	C1	B4	T-I	TL061CP	IC-227
U102	3 1/2 Digit Single Chip A/D Converter	E,F1	C3	INT	ITS 80062	LSI-22*
U103	CMos Quad 2-Input NAND Gate	E5,6	D3	NAT	C04011CN	IC-102*
U104	CMos Quad Exclusive-OR Gate	Several	D4	NAT	C04070BCM	IC-226*
U105	CMos Quad Exclusive-OR Gate	Several	D4	NAT	C04070BCM	IC-226*
U106	CMos Quad Exclusive-NOR Gate	Several	D4	RCA	CD4077BE	IC-228*
VR101	Diode, Low voltage ref, 1.2V, 10mA	C4	B3	INT	ICL 8069DCQ	DZ-62*
	* Anti-static protection and handling required.					

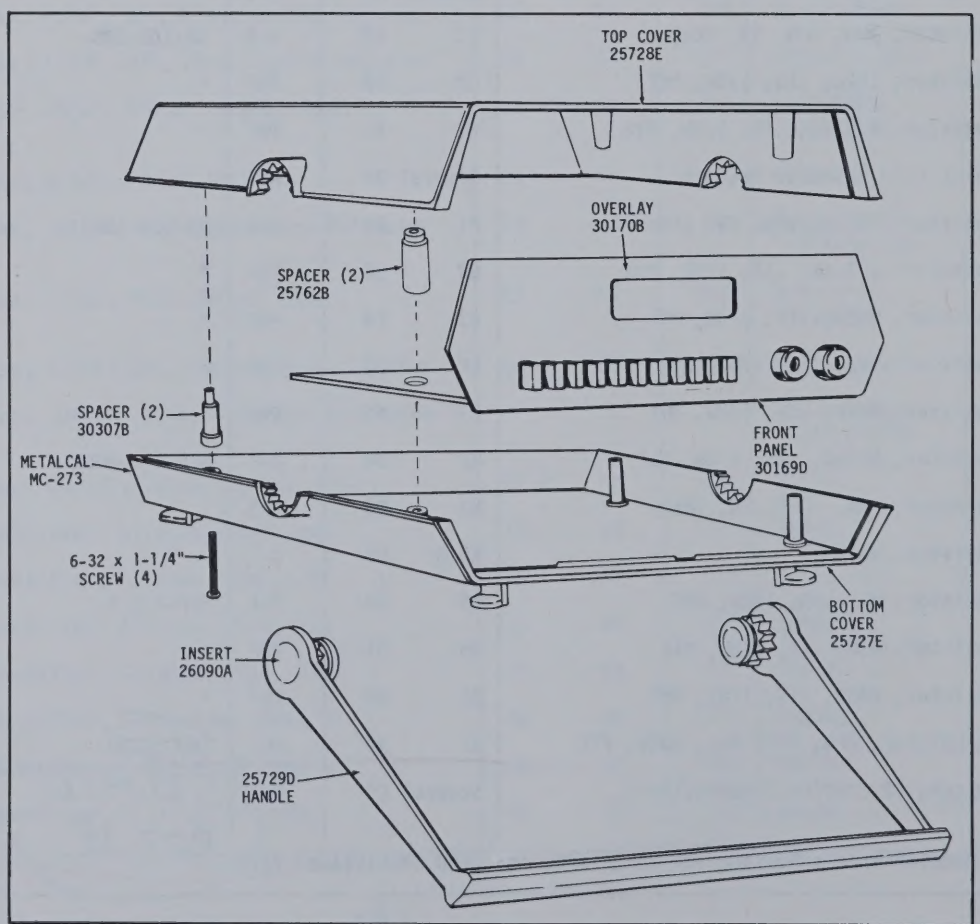


FIGURE 7-1. Covers and Panels.

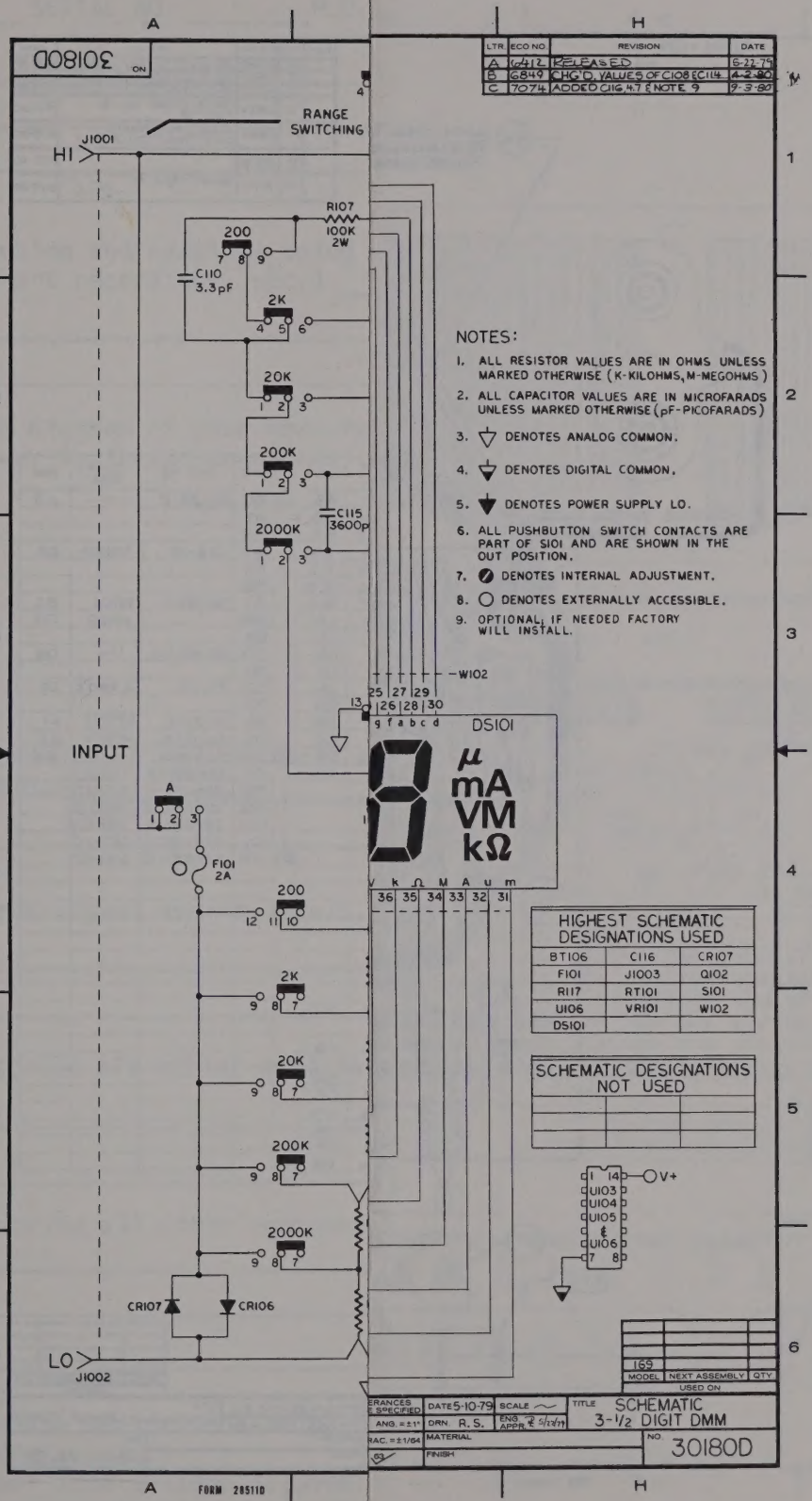

30180D
RANGE SWITCHING
J1001
HI
INPUT
LO
J1002
R107
100K
2W
200
2K
20K
200K
2000K
C110
3.3pF
C115
3600p
W102
DS101
μ
mA
VM
kΩ
F101
2A
CR107
CR106
U103
U104
U105
U106
V+
NOTES:
1. ALL RESISTOR VALUES ARE IN OHMS UNLESS MARKED OTHERWISE (K-KILOHMS, M-MEGOHMS)
2. ALL CAPACITOR VALUES ARE IN MICROFARADS UNLESS MARKED OTHERWISE (pF-PICOFARADS)
3. DENOTES ANALOG COMMON.
4. DENOTES DIGITAL COMMON.
5. DENOTES POWER SUPPLY LO.
6. ALL PUSHBUTTON SWITCH CONTACTS ARE PART OF S101 AND ARE SHOWN IN THE OUT POSITION.
7. DENOTES INTERNAL ADJUSTMENT.
8. DENOTES EXTERNALLY ACCESSIBLE.
9. OPTIONAL, IF NEEDED FACTORY WILL INSTALL.
LTR ECO NO. REVISION DATE
A 6412 RELEASED 5-22-79
B 6849 CHG'D. VALUES OF C108 EC114 4-2-80
C 7074 ADDED C116 4.7 & NOTE 9 9-3-80
HIGHEST SCHEMATIC DESIGNATIONS USED
BT106 C116 CR107
F101 J1003 Q102
R117 RT101 S101
U106 VR101 W102
DS101
SCHEMATIC DESIGNATIONS NOT USED
169
MODEL NEXT ASSEMBLY QTY
USED ON
DATE 5-10-79
DRN. R. S.
MATERIAL
FINISH
SCALE
TITLE SCHEMATIC 3-1/2 DIGIT DMM
NO. 30180D
FORM 28511D

TABLE 7-3 (Cont'd)
REPLACEABLE PARTS LIST

Circuit Desig.	Description	Location Sch.	Location Pcb.	Mfr. Code	Mfr. Desig.	Keithley Part No.
U101	Low-Power JFET-Input OP-AMP	C1	B4	T-I	TL061CP	IC-227
U102	3 1/2 Digit Single Chip A/D Converter	E,F1	C3	INT	ITS 80062	LSI-22*
U103	CMos Quad 2-Input NAND Gate	E5,6	D3	NAT	C04011CN	IC-102*
U104	CMos Quad Exclusive-OR Gate	Several	D4	NAT	C04070BCM	IC-226*
U105	CMos Quad Exclusive-OR Gate	Several	D4	NAT	C04070BCM	IC-226*
U106	CMos Quad Exclusive-NOR Gate	Several	D4	RCA	CD4077BE	IC-228*
VR101	Diode, Low voltage ref, 1.2V, 10mA	C4	B3	INT	ICL 8069DCQ	DZ-62*
	* Anti-static protection and handling required.					

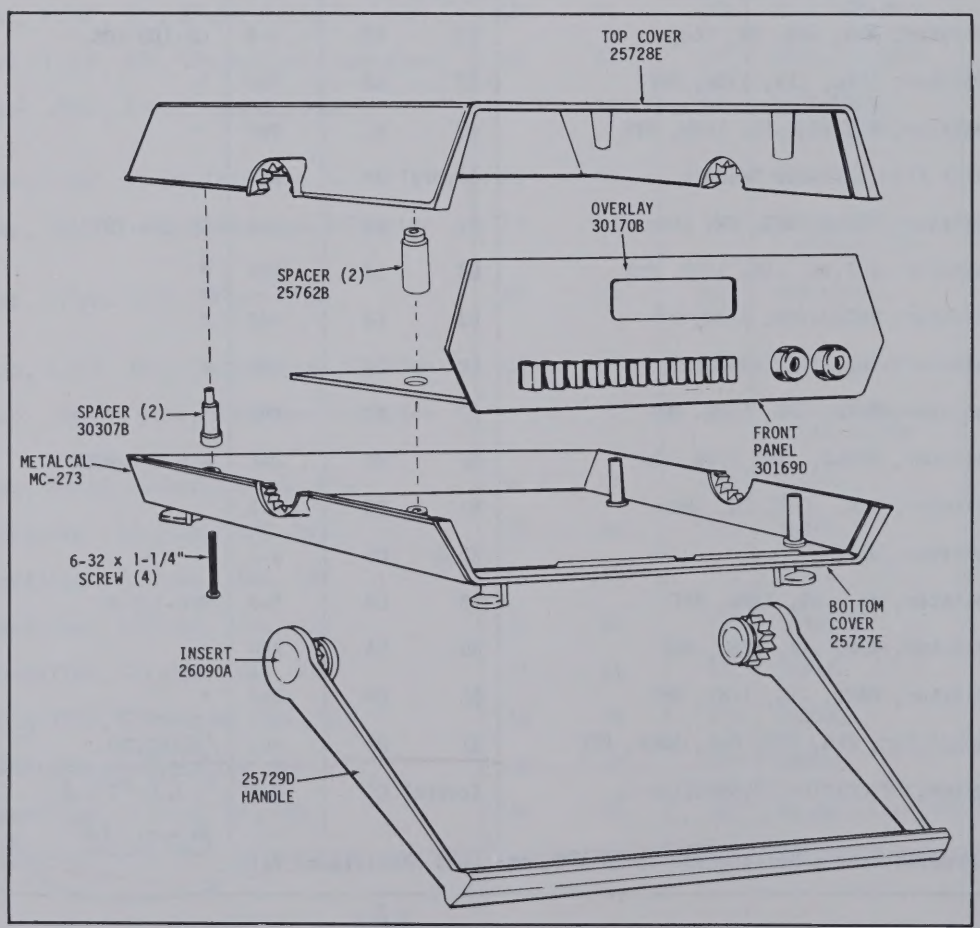
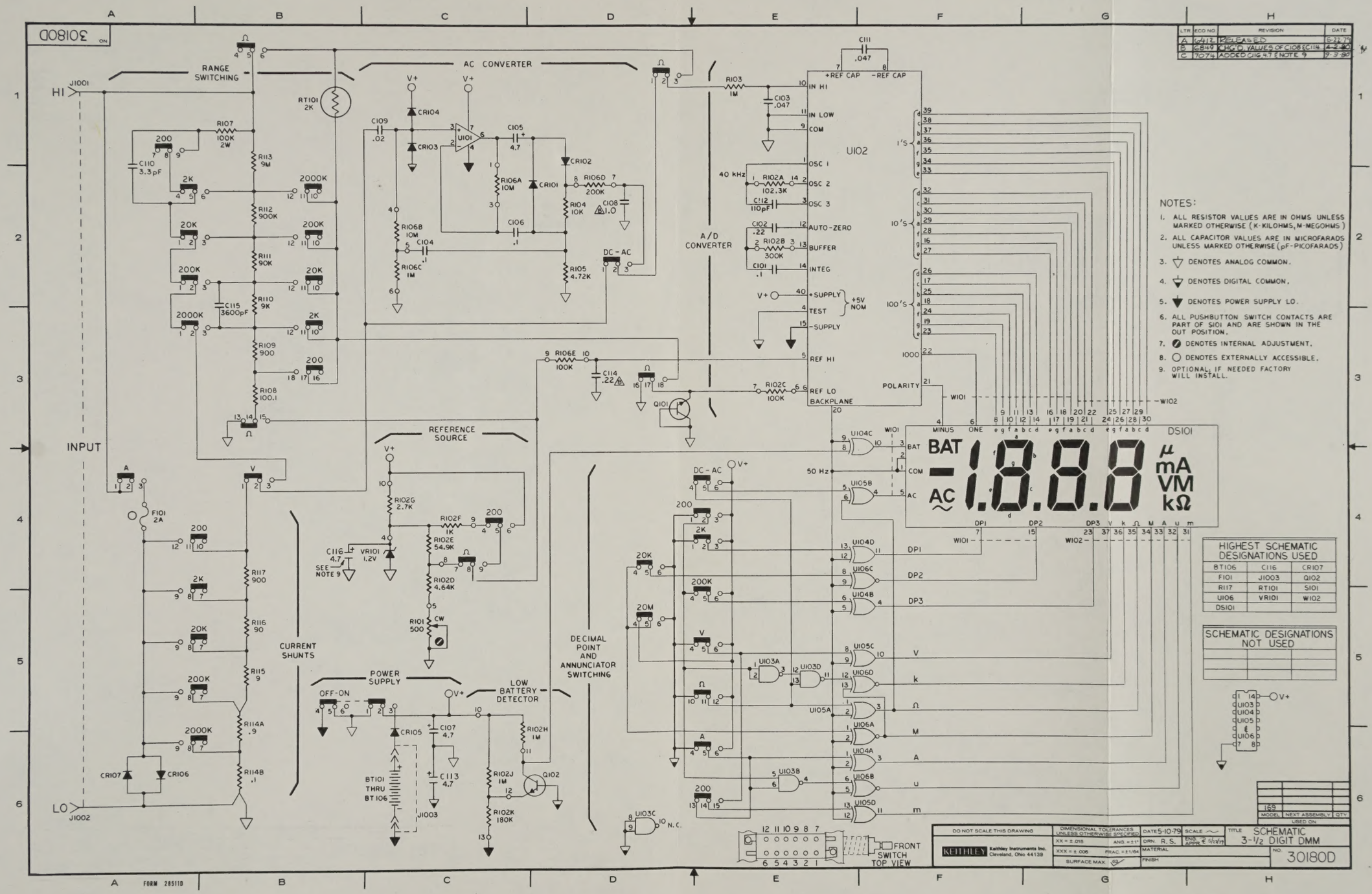


FIGURE 7-1. Covers and Panels.



LTR	ECO NO.	REVISION	DATE
A	6412	RELEASED	6-22-79
B	6849	CHG'D. VALUES OF C108 & C114	4-2-80
C	7074	ADDED C116, 47 & NOTE 9	9-3-80

NOTES:

1. ALL RESISTOR VALUES ARE IN OHMS UNLESS MARKED OTHERWISE (K-KILOHMS, M-MEGOHMS)
2. ALL CAPACITOR VALUES ARE IN MICROFARADS UNLESS MARKED OTHERWISE (pF-PICOFARADS)
3. ▽ DENOTES ANALOG COMMON.
4. ▽ DENOTES DIGITAL COMMON.
5. ▼ DENOTES POWER SUPPLY LO.
6. ALL PUSHBUTTON SWITCH CONTACTS ARE PART OF SI01 AND ARE SHOWN IN THE OUT POSITION.
7. ⊘ DENOTES INTERNAL ADJUSTMENT.
8. ○ DENOTES EXTERNALLY ACCESSIBLE.
9. OPTIONAL, IF NEEDED FACTORY WILL INSTALL.

HIGHEST SCHEMATIC DESIGNATIONS USED

BT106	C116	CR107
F101	J1003	Q102
R117	RT101	SI01
U106	VR101	W102
DSIO1		

SCHEMATIC DESIGNATIONS NOT USED

169	
MODEL	NEXT ASSEMBLY
USED ON	QTY.

DO NOT SCALE THIS DRAWING
DIMENSIONAL TOLERANCES UNLESS OTHERWISE SPECIFIED: XX ± .015 ANG. ± 1°; XXX ± .005 FRAC. ± 1/64; SURFACE MAX.
DATE 5-10-79 SCALE ~ DRN. R.S. ENG APPR.
MATERIAL FINISH
TITLE SCHEMATIC 3-1/2 DIGIT DMM
NO. 30180D
KEITHLEY Keithley Instruments Inc. Cleveland, Ohio 44139
FORM 28511D

ZONE	LTR	ECO NO.	REVISION	DATE
	B	6364	REVISED TO ARTWORK	4-10-79
	C	6412	[illegible]	5-22-79
	D	6621	CHG'D ITEM 6 FROM C278 TO C320	2-29-80
	E	6849	CHG'D ITEMS 12, 18 AND 38	4-2-80
	F	6889	ADDED ALTERNATE CONSTRUCTION OF R113	4-10-80
	G	7074		8-2-80
	H	7177	ADDED ITEM 81 GAL	10-17-80

(2) PC-509

(95) WIRE BLACK TO LO TERMINAL OF FH-18 FUSE HOLDER

(1) PC-508

CR107

ITEM	PART NO.	SCHEM. DESIG	ZONE
1	30177 D	HOLE SIZE	E3
2	30173C	HOLE SIZE	E2
3			
4			
B 5	C-306-.1	C101	B3
C 6	C-305-.22	C102	B3
7	C-305-.047	C103	B3
8	C-305-.1	C104	B4
9	C-179-4.7	C105	B4
B 10	C-305-.1	C106	B4
11	C-179-4.7	C107	B4
E 12	C-179-1.0	C108	B4
13	C-298-.02	C109	B4
F 14	C-308-3.3μF	C110	C4
15	C-305-.047	C111	D3
A 16	C-320-1100pF	C112	D3
17	C-179-4.7	C113	B3
E B 18	C-305-.22	C114	D3
B 19	C-64-3600P	C115	C4
20			
21			
22			
23			
24	RF-28	CR101	A4
25	"	CR102	A4
26	"	CR103	B4
27	"	CR104	B4
B 28	RF-39	CR105	A5
29	RF-34	CR106	E4
30	"	CR107	E4
31			
32			
33			
34	BH-28	J1003	A2
35			
36			
37			
E 38	TG-138	Q101	B3
39	TG-47	Q102	B3
40			

ITEM	PART NO.	SCHEM DESIG	ZONE
C 41	RP-97-500	R101	A3
42	TF-93	R102	B3
43	R-2-1M	R103	B3
44	R-179-10K	R104	B3
B 45	R-179-4.72K	R105	B3
46	TF-92	R106	B4
47	R-3-100K	R107	B4
C 48	R-179-100.1	R108	C4
49	R-179-900	R109	C4
50	R-179-9K	R110	C4
51	R-179-90K	R111	C4
52	R-135-900K	R112	D4
53	R-277-9M	R113	D5
54	R-278	R114	D5
55	R-61-9	R115	D4
56	R-179-90	R116	D4
57	R-179-900	R117	D4
B 58			
59			
60			
61			
62			
63			
64			
65			
66			
67			
68			
69			
70			
71	RT-5	RT101	B4
72			
73	30314B	S101	C5
74			
75	IC-227	U101	B4
76	LS1-22	U102	C3
77	IC-102	U103	D3
78	IC-226	U104	D4
79	"	U105	D4
C 80	IC-228	U106	D4

ITEM	PART NO.	SCHEM. DESIG.	ZONE
H 81	CC-38-2	——	A3
82			
83			
84	DZ-62	VR101	B3
85			
86			
87	SC-82-1	W101	B2
88	"	W102	D2
89			
90	SO-84-40	——	D3
91			
92	FH-12	2 REQ'D	D5
93			
94	SC-71-2	LENGTH TO SUIT	A1
95	SC-71-0	LENGTH TO SUIT	E2
B 96	30315A	——	B4
97	29465C-3	1 REQD	
98	29465C-4	1 REQD	
99	29465C-5	1 REQD	
100	29465C-6	1 REQD	
101	29465C-7	1 REQD	
B 102	29465C-2	6 REQD	

MODEL	NEXT ASSEMBLY	QTY.
169		1
USED ON		

DO NOT SCALE THIS DRAWING

DIMENSIONAL TOLERANCES UNLESS OTHERWISE SPECIFIED: XX = ± .015, ANG. = ±1°; XXX = ± .005, FRAC. = ±1/64; SURFACE MAX. 63

DATE 3-13-79 | SCALE 2:1 | DRN. [illegible] | ENG APPR R.B | MATERIAL | FINISH

KEITHLEY INSTRUMENTS CLEVELAND, OHIO

TITLE: COMPONENT LAYOUT, PC-508

NO. 30176D

KEITHLEY INSTRUMENTS, INC.
28775 AURORA ROAD
CLEVELAND, OHIO 44139

SERVICE FORM

MODEL NO. _____ SERIAL NO. _____ P.O. NO. _____ DATE _____ R-

NAME _____ PHONE _____

COMPANY _____

ADDRESS _____ CITY _____ STATE _____ ZIP _____

1. Describe problem and symptoms using quantitative data whenever possible (enclose readings, chart recordings, etc.) _____

_____

_____ (Attach additional sheets as necessary).

2. Show a block diagram of your measurement system including all instruments connected (whether power is turned on or not). Also describe signal source.

3. List the positions of all controls and switches on both front and rear panels of the instrument. _____

_____

4. Describe input signal source levels, frequencies, etc. _____

_____

_____

5. List and describe all cables used in the experiment (length, shielding, etc.).

_____

_____

6. List and describe all other equipment used in the experiment. Give control settings for each. _____

_____

_____

7. Environment:
   Where is the measurement being performed? (Factory, controlled laboratory, out-of-doors, etc.) _____
   What power line voltage is used? _____ Variation? _____ Frequency? _____
   Ambient temperature? _____ °F. Variation? _____ °F. Rel. Humidity? _____
   Other _____

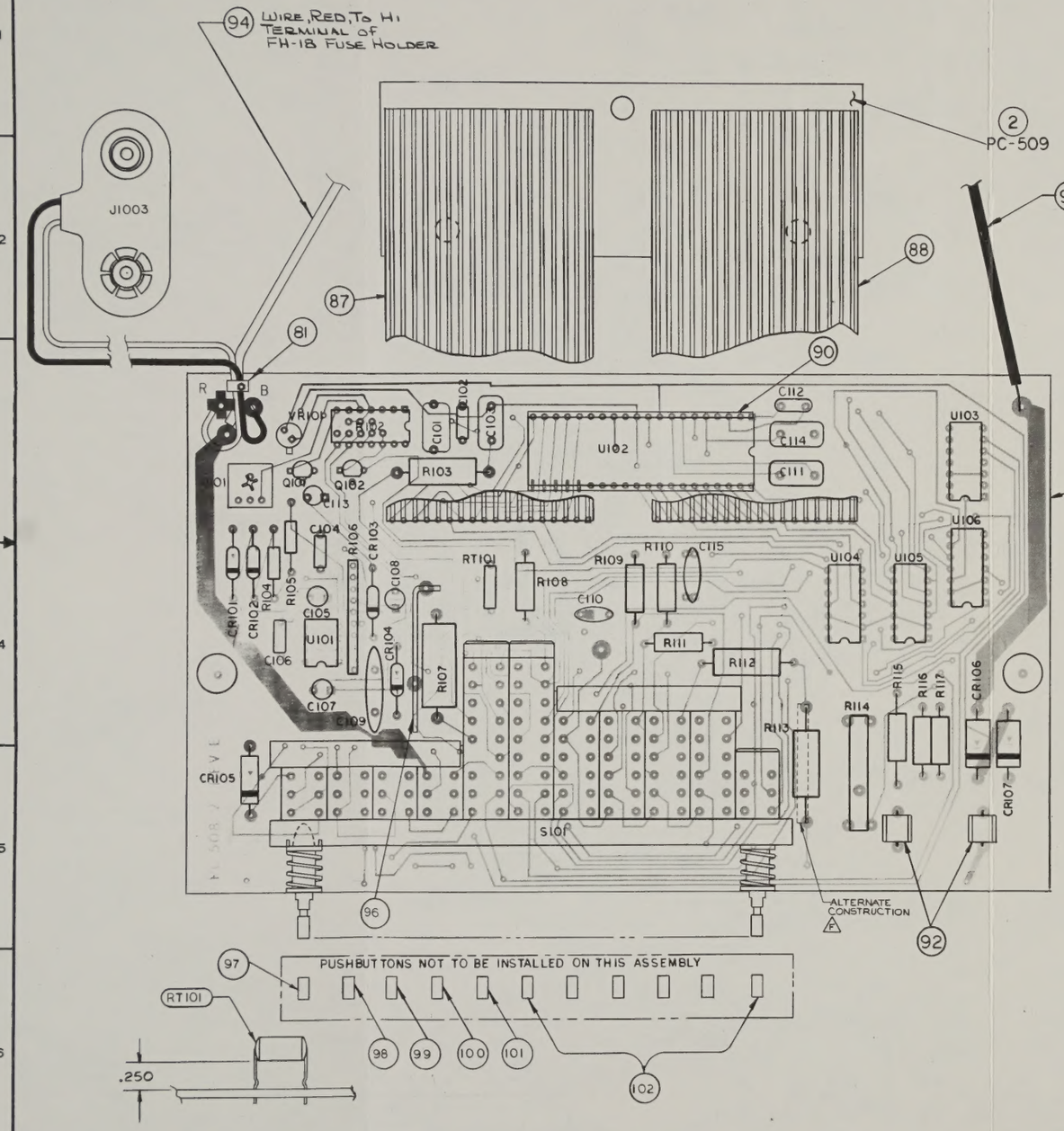
8. Additional Information. (If special modifications have been made by the user, please describe below.) _____

_____

REV 0774

30176D

ZONE	LTR	ECO NO.	REVISION	DATE
	B	6304	REVISED TO ART WORK	8-10-79
	C	6416	[illegible]	9-22-79
	D	6621	CHG'D ITEM FROM C-278 TO C-320	2-29-80
	E	6849	CHG'D ITEMS 12, 18 AND 38	4-2-80
	F	6889	ADDED ALTERNATE CONSTRUCTION OF R113	4-10-80
	G	7074		8-8-80
	H	7177	ADDED ITEM 81 GaL	10-17-80



ITEM	PART NO.	SCHEM DESIG	ZONE
1	30117D	HOLE SIZE	E3
2	30173C	HOLE SIZE	E2
3			
4			
B 5	C-306-.1	C101	B3
A 6	C-305-.22	C102	B3
7	C-305-.047	C103	B3
8	C-305-.1	C104	B4
9	C-179-4.7	C105	B4
B 10	C-305-.1	C106	B4
11	C-179-4.7	C107	B4
E 12	C-179-1.0	C108	B4
13	C-298-.02	C109	B4
A 14	C-308-3.3pF	C110	C4
15	C-305-.047	C111	D3
B 16	C-320-1100pF	C112	D3
17	C-179-4.7	C113	B3
E B 18	C-305-.22	C114	D3
B 19	C-64-3600p	C115	C4
20			
21			
22			
23			
24	RF-28	CR101	A4
25	"	CR102	A4
26	"	CR103	B4
27	"	CR104	B4
B 28	RF-39	CR105	A5
29	RF-34	CR106	E4
30	"	CR107	E4
31			
32			
33			
34	BH-28	J1003	A2
35			
36			
37			
E 38	TG-138	Q101	B3
39	TG-47	Q102	B3
40			

ITEM	PART NO.	SCHEM DESIG	ZONE
E 41	RP-97-500	R101	A3
42	TF-93	R102	B3
43	R-2-1M	R103	B3
44	R-179-10K	R104	B3
B 45	R-179-4.72K	R105	B3
46	TF-92	R106	B4
47	R-3-100K	R107	B4
A 48	R-179-100.1	R108	C4
49	R-179-900	R109	C4
50	R-179-9K	R110	C4
51	R-179-90K	R111	C4
52	R-135-900K	R112	D4
53	R-277-9M	R113	D5
54	R-278	R114	D5
55	R-61-9	R115	D4
B 56	R-179-90	R116	D4
57	R-179-900	R117	D4
B 58			
59			
60			
61			
62			
63			
64			
65			
66			
67			
B 68			
69			
70			
71	RT-5	RT101	B4
72			
73	30314B	S101	C5
74			
75	IC-227	U101	B4
76	LS1-22	U102	C3
E 77	IC-102	U103	D3
78	IC-226	U104	D4
79	"	U105	D4
A 80	IC-228	U106	D4

ITEM	PART NO.	SCHEM DESIG.	ZONE
A 81	CC-38-2	——	A3
82			
83			
84	DZ-62	VR101	B3
85			
86			
87	SC-82-1	W101	B2
88	"	W102	D2
89			
90	SO-84-40	——	D3
91			
92	FH-12	2 REQ'D	D5
93			
94	SC-71-2	LENGTH TO SUIT	A1
95	SC-71-0	LENGTH TO SUIT	E2
A 96	30315A	——	B4
97	29469C-3	1 REQ'D	
98	29465C-4	1 REQ'D	
99	29465C-5	1 REQ'D	
100	29465C-6	1 REQ'D	
101	29465C-7	1 REQ'D	
A 102	29465C-2	6 REQ'D	

MODEL	NEXT ASSEMBLY	QTY
169	USED ON	

DO NOT SCALE THIS DRAWING

KEITHLEY INSTRUMENTS CLEVELAND, OHIO

DIMENSIONAL TOLERANCES UNLESS OTHERWISE SPECIFIED: XX = ± .015 ANG. = ±1°; XXX = ± .005 FRAC. = ±1/64; SURFACE MAX. 63

DATE 3-13-79 DRN. [illegible] ENG APPR. R.B

SCALE 2:1

MATERIAL

FINISH

TITLE COMPONENT LAYOUT, PC-508

NO. 30176D

FORM 285110

KEITHLEY INSTRUMENTS, INC.
28775 AURORA ROAD
CLEVELAND, OHIO 44139

SERVICE FORM

MODEL NO. _____ SERIAL NO. _____ P.O. NO. _____ DATE _____ R-

NAME _____ PHONE _____

COMPANY _____

ADDRESS _____ CITY _____ STATE _____ ZIP _____

1. Describe problem and symptoms using quantitative data whenever possible (enclose readings, chart recordings, etc.) _____

_____

_____ (Attach additional sheets as necessary).

2. Show a block diagram of your measurement system including all instruments connected (whether power is turned on or not). Also describe signal source.

3. List the positions of all controls and switches on both front and rear panels of the instrument. _____

_____

4. Describe input signal source levels, frequencies, etc. _____

_____

_____

5. List and describe all cables used in the experiment (length, shielding, etc.).

_____

_____

6. List and describe all other equipment used in the experiment. Give control settings for each. _____

_____

_____

7. Environment:
   Where is the measurement being performed? (Factory, controlled laboratory, out-of-doors, etc.) _____
   What power line voltage is used? _____ Variation? _____ Frequency? _____
   Ambient temperature? _____ °F. Variation? _____ °F. Rel. Humidity? _____
   Other _____

8. Additional Information. (If special modifications have been made by the user, please describe below.) _____

_____

REV 0774

KEITHLEY

Keithley Instruments, Inc./28775 Aurora Road/Cleveland, Ohio 44139/(216) 248-0400/Telex: 98-5469

Keithley Instruments GmbH/Heiglhofstrasse 5/D-8000 Munchen 70/(089) 714-40-65/Telex: 521 21 60

Keithley Instruments, Ltd./1, Boulton Road/GB-Reading, Berkshire RG2 ONL/(0734) 86 12 87

Keithley Instruments SARL/44, Rue Anatole France/F-91121 Palaiseau Cedex/01-014-22-06/Telex: (842) 204188